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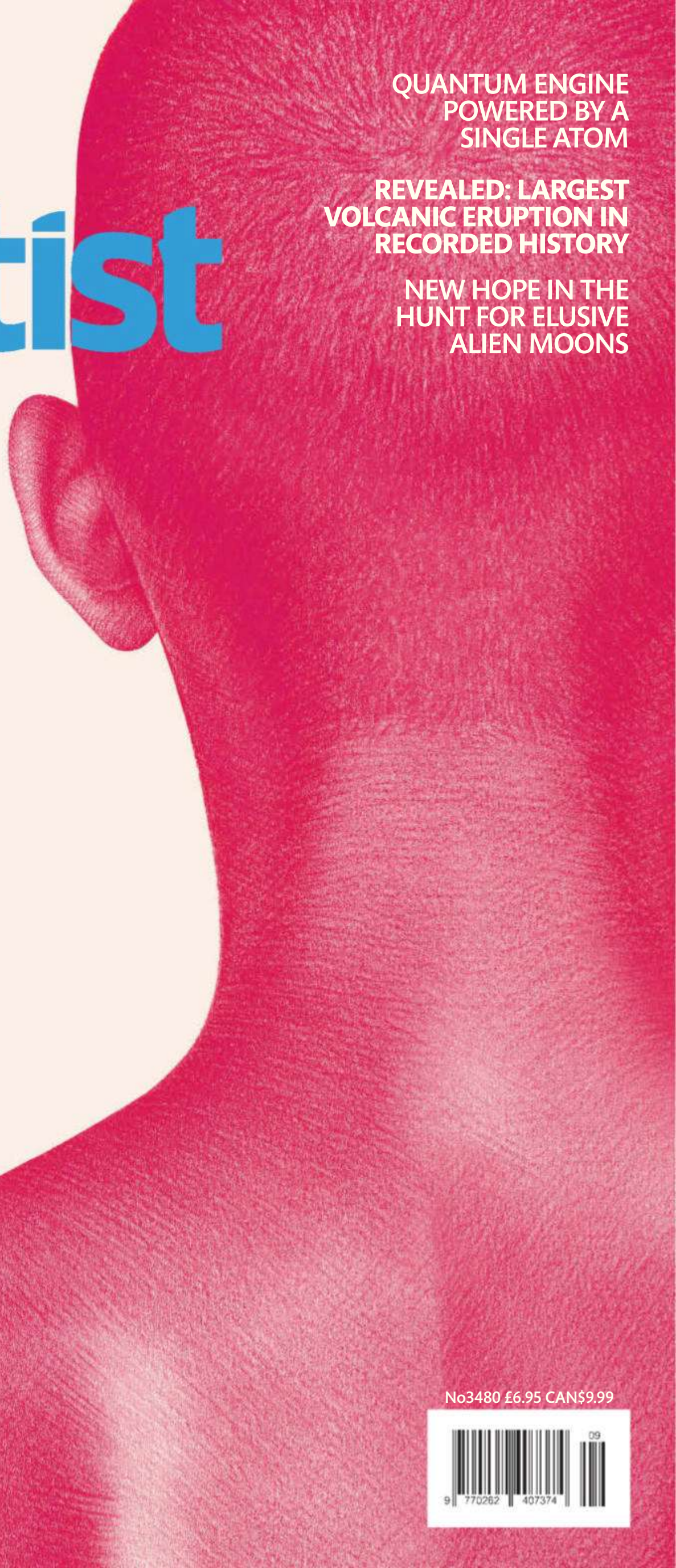

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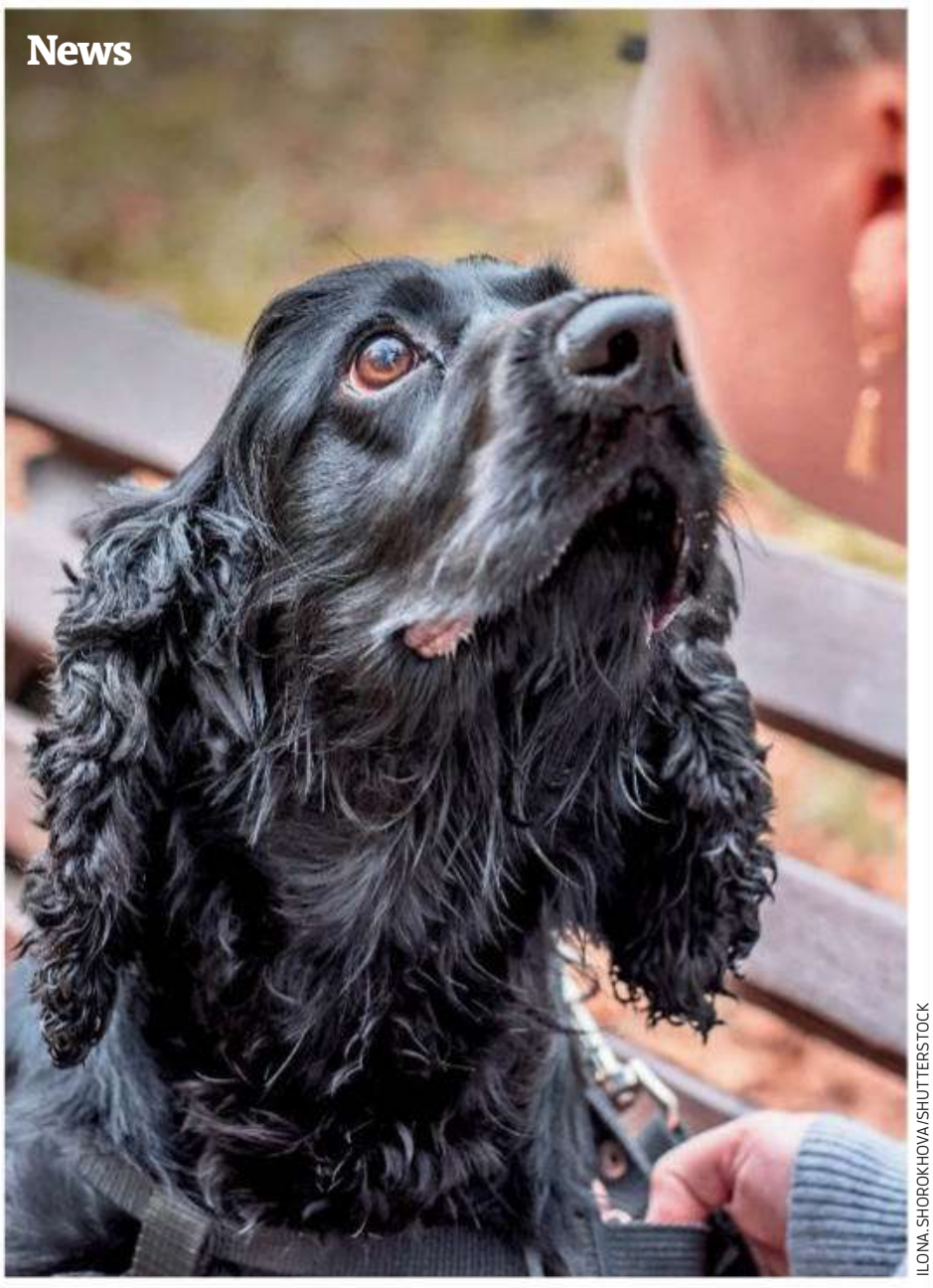

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Elsewhere on New Scientist

Virtual event

The road to conscious machines

Public debate about the future of AI is often centred on the idea of a dystopian robot takeover. Michael Wooldridge, a computer scientist at the University of Oxford, will instead explore how our anxieties distract us from the immediate risks that this technology poses – from algorithmic bias to fake news – revealing the real, life-changing potential of AI. This subscriber-only virtual event takes place on 12 March at 6pm GMT/1pm EST.

newscientist.com/events

Weekender

The science of the Jurassic Coast: Dorset and Devon, England

Join expert geologists and fossil hunters as you explore how continents collide and strange creatures evolve. Go on a coastal cruise and hear astrobiologist Lewis Dartnell discuss the mysteries of deep time. This three-day tour starts on 17 May and costs £899.

newscientist.com/tours

Podcast

Weekly

The team discuss what a year of record-breaking ocean temperatures means for global warming. They reveal how a "unicorn" in the world of black holes has excited physicists. Hear why ADHD may have evolved and why it has stuck around. Plus, find out why the future of AI "deepfake" technology looks grim.

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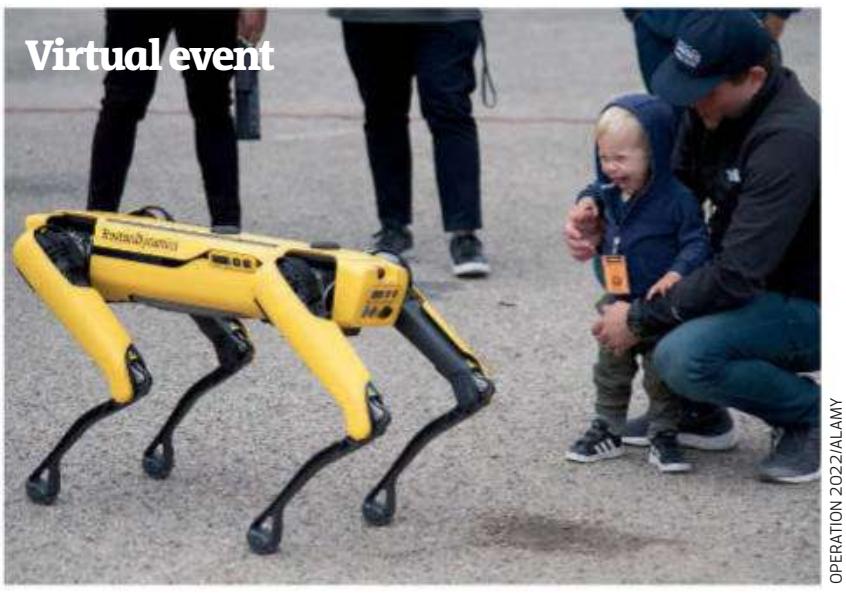
Fossil hunting Explore ancient rock strata at Dorset's Dulworth Cove



OPERATION 2022/ALAMY

Good dog? Why robots aren't the biggest worry when it comes to AI

Video

Disconnected nature

Canadian photographer Edward Burtynsky explores the ways that humans have affected our planet using large-format images shot from above. Detailed landscapes scarred by mining, farming and construction are revealed "in a way that you've probably never seen them", he says. *Extraction / Abstraction* is on at the Saatchi Gallery in London until 6 May.

youtube.com/newscientist

Newsletter

Fix the Planet

As electric vehicle sales have soared, so has investment in the electric charging industry. But what if there were a better way to re-juice your car? Battery swapping – where you pull up at a service station and quickly exchange your flat battery for a full one – is a simple but effective idea that is enjoying a resurgence.

newscientist.com/fix

Podcast

"Common traits of ADHD can drive people to move on before the land is over-harvested"

Essential guide

Your mind underpins your every experience and is integral to both the internal feeling of being "you" and how others perceive you. It is so familiar, yet extremely hard to pin down. Unravel the truth about your inner world with the latest *New Scientist Essential Guide*. Buy in print now.

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An altered diet

If we can't give up meat, we must make it less damaging

EATING meat is a major contributor to two of the greatest problems humanity faces: global warming and the loss of biodiversity. Farming is one of the main sources of greenhouse gas emissions, while the amount of land turned over to grow food for livestock leaves less space for wildlife.

This is why many studies have highlighted the massive environmental benefits there would be if only people ate less meat. A plant-based diet has a much lower footprint in terms of carbon emissions and land. What's more, there are also ethical and health arguments for such a diet.

Yet global meat consumption continues to rise. It isn't just that there are more people on the planet, we are also eating nearly twice as much meat per person as in the 1960s.

That means methods of producing this food more efficiently offer a path to minimise its environmental impacts. One way to do this is genetic modification.

"Will people embrace the idea of eating gene-edited meat? There is no rational reason not to"

While plants altered in this way are now widely grown and consumed, the same isn't true for farm animals.

But this looks set to change. A company has created hundreds of pigs gene edited to be resistant to porcine reproductive and respiratory syndrome, or PRRS (see page 8). These animals won't just boost farmers' profits. By reducing the loss of animals caused by PRRS, they will also shrink the carbon and land footprint per kilo of pork.

Researchers are also modifying livestock in other ways, such as to be more heat tolerant and to belch out less methane. But will people embrace the idea of eating gene-edited meat? There is no rational reason not to, given that the genetic changes made with techniques such as CRISPR can be more minor than the dozens of natural mutations in DNA that occur in every single animal. But food choices are seldom just about rationality.

However, in places such as the US, meat from CRISPR animals won't usually need to be labelled. In other words, the gene-editing revolution may not be advertised. That might not be a bad thing ▮

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Red Planet plans
Martian soil could be turned into fibres as strong as steel **p18**

ROV SUBASTIAN/SCHMIDT OCEAN IN

Marine biology

Deep-sea fish is radiant in red

This vibrant sea toad in the *Chaunacops* fish genus was spotted about 1400 metres underwater on a seamount off the coast of Chile in the Pacific Ocean by a remotely operated vehicle from research vessel Falkor (too). The expedition may have discovered more than 100 new species, including deep-sea corals, glass sponges, sea urchins and squat lobsters, as well as four new seamounts.

Animals

Gene-edited pork on the menu

CRISPR pigs with genetically engineered immunity to a costly disease could be approved within a year and their meat put on sale not long after, discovers **Michael Le Page**

PIGS that are immune to a disease estimated to cost farmers $2.7 billion a year globally look set to become the first genetically modified farm animals to be used for large-scale meat production.

"We could very well be the first," says Clint Nesbitt at international breeding company Genus, which has created hundreds of the CRISPR-edited pigs in preparation for a commercial launch.

He is confident that the animals, which have been modified to have immunity to porcine reproductive and respiratory syndrome (PRRS), will be given the go-ahead by US regulators by early 2025 or sooner. "I think by and large the farmers are quite excited to have it, because this is a fairly devastating disease," says Nesbitt.

That approval process by the Food and Drug Administration has been going on for several years and is nearing completion, says Nesbitt. "We don't have any reason to think that the FDA will not approve the pigs."

Genus is also applying for the regulatory green light to be given in major export markets for US pork, from Mexico to China, and the full-scale commercial launch will follow this, he says. "If those pork products end up in countries where they have not yet approved the pig, that causes all kinds of disruptions," says Nesbitt. "I think we still have two years to go before we're likely to start actually selling the pigs."

Immune damage

PRRS is caused by a virus that may lead to no symptoms in some animals, but severe disease in others. It can damage the immune system, making pigs vulnerable to other infections that have to be treated with antibiotics.

GENUS PIC

Gene-edited pigs are protected from porcine reproductive and respiratory syndrome

There are vaccines available, but they only reduce the severity of symptoms, which is why gene editing is an attractive alternative.

The virus infects cells by binding to a small part of a protein called CD163. Work at the Roslin Institute in the UK showed that using CRISPR gene editing to remove the DNA coding for this part of the protein prevents infection while allowing the protein to continue to function in the pigs in all other ways.

"They are completely immune to the virus," says Nesbitt. "And we have not found anything else that is impacted in the pig."

Now, in facilities in the US, Genus has made this gene edit in four different breeding lines of pigs, although this wasn't straightforward. Only about a fifth of the piglets created by Genus had the desired edit and only in some cells in the body, not all – which is known as mosaicism.

A few also had unintended changes elsewhere in the genome as a result of the editing process.

Further rounds of breeding were needed to create animals with the desired change in both copies of the gene and with no unintended changes (*The CRISPR Journal*, doi.org/mh36).

$2.7bn

Cost of porcine reproductive and respiratory syndrome annually

2025

When genetically immune pigs could be given the go-ahead

The difficulty and expense of creating a genetically diverse population of animals ready for mass production is partly why modified farm animals aren't yet used for meat or dairy production. As far as *New Scientist* is aware, Genus is the first company to overcome this hurdle.

Off to market

The firm will sell semen rather than pigs, says Nesbitt. This means the first generation of animals produced from this won't have immunity to PRRS, as only one of the two copies of the *CD163* gene in such offspring will have the edit. Further breeding will be required to produce animals with the edit in both copies, which could take several years.

Genus will also provide a test that reveals if pigs have the edit, and whether they have it in one or both copies. In the US, meat from the pigs won't have to be labelled.

In the UK, the National Pig Association has called on the government to speed up plans to allow the production and sale of gene-edited plants and animals in England so the PRRS-resistant pigs become available to farmers sooner. The introduction of such pigs would help avoid animal suffering, it says.

But not all animal welfare organisations support the idea. "Keeping animals crowded together, and in stressful conditions, provides an ideal environment for pathogens to spread and evolve," says Catherine Jadav at Compassion in World Farming. "If PRRS-resistant pigs are used to perpetuate the current highly intensive model of pig farming, then other diseases will continue to develop – bringing disease after disease that 'requires' new gene-edited animals." ▮

Space

White dwarf star has a metallic scar after eating a planet

Leah Crane

ASTRONOMERS have found a white dwarf star with a strange metallic scar on its surface. This blemish probably formed when the star ripped up and ate a small planet in its orbit.

ESO/L. CALÇADA

An artist's impression of the star WD 0816-310, with a dark scar on its surface, near the pole

White dwarfs often have traces of metal in their atmospheres, which come from planets that have fallen into the star. It has long been thought that the metals should be distributed evenly across the surfaces of these so-called polluted white dwarfs, but Jay Farihi at University College London and his colleagues have found one with an odd, concentrated patch of metal.

The researchers monitored the star, called WD 0816-310, over two months using the Very Large Telescope in Chile. They found an opaque patch of metal over one of the white dwarf's magnetic poles, blocking some of the star's light as it rotated. This position indicates that the material was probably funnelled into the star by its magnetic field (*The Astrophysical Journal Letters*, doi.org/mh5c). "This is an identical process to the one that causes the aurora on Earth: charged particles following the magnetic field to the surface," says Farihi.

The planet that WD 0816-310 destroyed was small – probably around the same size as the asteroid Vesta in our solar system, which is about 525 kilometres across. Its innards are now displayed prominently on the star, which could make it relatively easy to study what its geochemistry was like before it was devoured. ▮

Evolution

ADHD may have helped early humans to forage effectively

Chen Ly

ADHD may have evolved in hunter-gatherer societies because it was advantageous for foragers. Traits that are commonly associated with the condition, such as being impulsive, might have encouraged some foragers to move on from areas with depleting resources sooner than those without the condition.

ADHD affects people's behaviour, which may result in them acting on impulse or having difficulty concentrating. Its exact cause isn't fully understood, but it tends to run in families.

The condition's origin is similarly unclear, says Arjun Ramakrishnan at the Indian Institute of Technology Kanpur. "Is it a legacy of the hunter-gatherer world?"

To explore this further, Ramakrishnan, David Barack at the University of Pennsylvania and their colleagues recruited 506 people in the US to play an online foraging game. Players collected as many berries as they could in 8 minutes by hovering their cursor over bushes.

They were given the choice to either stay at a bush or to try their luck by leaving for another, which may have more or fewer berries. Moving to a new bush also incurred a brief time out, so the players had to balance the benefits of potentially getting more berries with the time lost due to moving on.

Before playing the game, the participants did a survey to assess if they had ADHD symptoms, such as difficulty concentrating and restlessness.

Those with ADHD symptoms spent about 4 seconds less hovering over any given bush than those without signs of the condition, which resulted in the former group collecting an average of 602 berries compared with 521 (*Proceedings of the Royal Society B*, doi.org/mh38).

The findings suggest that the selective pressures facing early hunter-gatherer communities, including a scarcity of resources, may have driven ADHD's evolution. There will have been foraging situations where it was better to stay than to move on, but in some scenarios, the tendency to leave may have been an advantage, says Barack.

"Humans and other apes are quite sophisticated foragers, but like almost every other animal, we tend to stay too long in a patch," he says. "So moving on early is beneficial because it cuts down on that overharvesting, which might be where the impulsivity characteristics of ADHD come in useful."

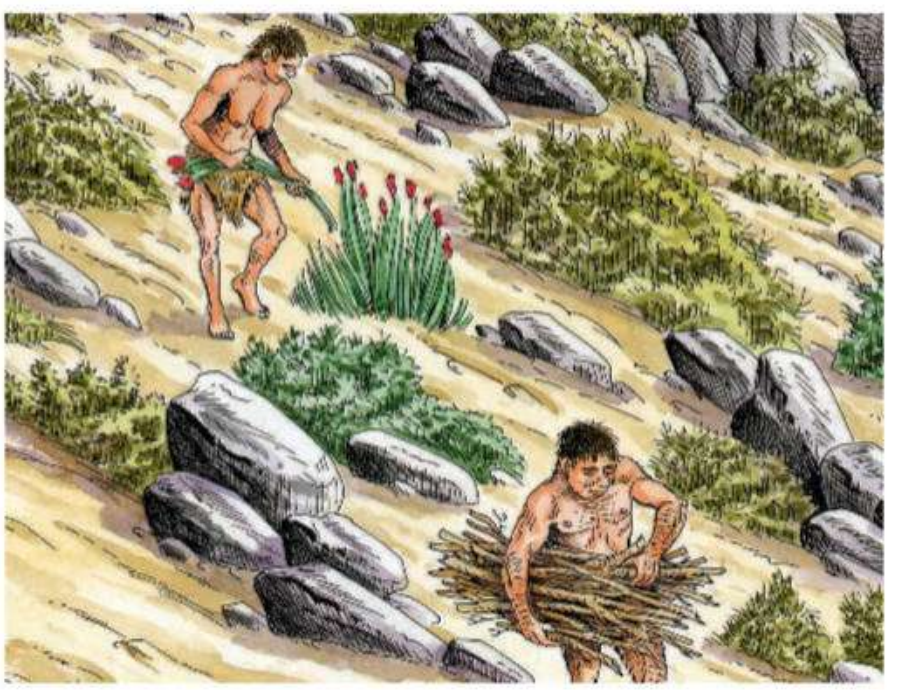
Many people around the world no longer forage for food, but a similar decision-making process may occur in other situations. If you are studying for an exam, you might start by looking at one resource. If that isn't helping you understand the topic, you may quickly switch to another resource, which could turn out to be more helpful, says Barack.

"Humans and other apes are quite sophisticated foragers, but we tend to stay too long in a patch"

"Determining exactly how behaviours associated with ADHD may have been adaptive within past environments is difficult, and these results are compelling in that they demonstrate measurable differences in the foraging strategies employed by individuals with and without ADHD," says Dan Eisenberg at the University of Washington in Seattle.

But Annie Swanepoel at North East London NHS Foundation Trust says that the berries in the foraging task were plentiful and therefore not reflective of the scarcity of resources experienced by many early hunter-gatherers. ▮

Impulsive behaviour may have led people to avoid overharvesting



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Environment

Tree-planting effects overestimated

Planting forests to absorb more carbon dioxide is seen as key in slowing climate change, but the impact of new trees seems to be lower than expected, finds **Michael Le Page**

GROWING trees will help limit further warming of the planet by soaking up carbon dioxide – but not quite as much as we thought. The climate benefits on a global level could be some 15 to 30 per cent smaller than previous estimates because of other effects, such as trees absorbing sunlight.

"We are not saying don't plant trees," says James Weber at the University of Sheffield, UK. It is just the climate benefits aren't as big as we thought, he says.

The impact that trees have depends in part on what other actions are taken to tackle climate change. The more that is done, the greater the benefits of planting forests, Weber and his colleagues have shown. "It's more positive and more efficient if we also do other things as well," says Weber.

It has long been known that plants can have both warming and cooling effects. In particular, dark foliage can cause warming by soaking up light that would be reflected back into space if no foliage were present. This effect is strongest where trees replace snow and ice, but can occur in other situations too.

Plants also emit volatile organic compounds into the air. "They are the chemicals that produce the smell of the forest," says team member James King, also at the University of Sheffield.

These biogenic compounds can affect the climate in many ways. One key example is that they can react with chemicals in the atmosphere that would otherwise react with methane. "So methane hangs around for longer, and methane is a strong greenhouse gas," says Weber.

The compounds released by plants can also react with nitrogen oxides to form ozone, another greenhouse gas.

These effects result in more warming. But biogenic compounds can also form aerosol particles that reflect sunlight and thus have a cooling effect.

To get an idea of the overall impact of forest planting on the climate, the team included these processes and others in a climate model where all available land is forested. That means trees in areas that are currently grassland, for instance, but not on farmland or in built-up areas.

"Preventing deforestation is a far more efficient way to mitigate climate change than reforestation"

"To our knowledge, this is the first time this has been done on a global scale and with a plausible forestation scenario," says King.

The researchers modelled two scenarios. In one, little is done to tackle climate change besides tree planting. In this case, the amount of warming avoided by planting forests was 23 to 31 per cent less, compared with estimates based on CO_2 removal only, once the other forest effects were taken into account. In the second scenario, strong action is taken to reduce further warming. In this case, the amount of avoided warming was only 14 to 18 per cent less.

One reason for the difference is that cutting fossil fuel emissions will reduce aerosols from air pollution. In a polluted world, adding more aerosols from forests doesn't make much difference, but in a cleaner world, the cooling effect is larger.

The model is still incomplete and doesn't include all feedback effects, the team acknowledges. For instance, it includes the greenhouse effect of ozone, but not its effect on vegetation. High levels of ozone can kill trees, so less CO_2 is removed from the atmosphere. The model also doesn't include the effect of wildfires (*Science*, doi.org/mh39).

"It's very, very complex," says King. "It's not really possible in one study to consider every single set of feedbacks."

"Importantly, the study shows that preventing deforestation is a far more efficient way to mitigate climate change compared to reforestation, and should therefore be prioritised," says Stephanie Roe, a climate scientist at environmental organisation WWF in Washington DC.

The bigger picture

Another missing feedback in the model is the cooling effect of water evaporating from leaves, says Roe, which can be large in tropical regions. So while the climate benefits of forestation might have been overestimated, this study still doesn't give the full picture, she says.

What's more, forestation has numerous other benefits for people and wildlife, including reducing erosion, maintaining water supplies and water quality, providing food and jobs, and reducing local heat extremes. "Forestation, and specifically reforestation in forest biomes with native species, is absolutely worth pursuing," says Roe.

"We have always known that forests have warming effects under certain conditions and they have cooling effects under others. What this study shows is that the overwhelming net effect of forests is a cooling one," says Thomas Crowther at ETH Zurich in Switzerland.

"But most importantly, even if they didn't have such a cooling impact, we would still need to save natural forests to support Earth's biodiversity, and the billions of people who depend on them," he says. ▮

ERNESTO BENAVIDES/AFP VIA GETTY IMAGES

Trees being planted in the northern Peruvian Amazon rainforest to fight deforestation in the area

Space

Moon landers make giant leap for lunar exploration, despite two small falls

Leah Crane

TWO recent landers on the moon have ended up lying on their sides, but appear to be functioning surprisingly well regardless.

The Smart Lander for Investigating Moon (SLIM), launched by the Japan Aerospace Exploration Agency (JAXA), touched down on the moon on 19 January, marking a milestone for Japan as its first lunar lander. It has since survived the cold lunar night, reviving on 25 February.

Meanwhile, US firm Intuitive Machines landed its Odysseus spacecraft on the lunar surface on 22 February, becoming the first private company to successfully put a spacecraft on the moon.

During descent, both landers ended up on their sides. Despite this, Odysseus's solar panels have been functioning since it landed. However, the antenna that is supposed to point towards Earth to transmit data isn't oriented correctly, slowing the flow of information. Odysseus has been

INTUITIVE MACHINES

An image taken by the Odysseus lander just before it touched down on the moon

collecting data and slowly sending images back to Earth, but its solar panels will soon be bathed in darkness as lunar night falls.

"The batteries will attempt to keep the vehicle warm and alive, but eventually it'll fall into a deep cold," said mission director Tim Crain in a press conference on 23 February. "The next time the sun illuminates the solar arrays, we'll turn our dishes to the moon, just to see if the radios and the batteries and the flight computers survive." As *New Scientist* went to press, Odysseus is expected to stop transmitting on 27 February.

The two landers are both near the moon's south pole, but are far enough away from each other that their two week-long lunar days begin and end at different times – as the sun goes down on Odysseus, it will still be midday where SLIM is settled.

Because SLIM was also on its side when it landed, its solar panels weren't collecting any sunlight, so operators shut it down to preserve battery life a few hours after its landing. Nine days later, the panels became illuminated as the sun moved across the sky, but only a few days later, the lander entered lunar night, with temperatures dropping as low as -133°C – too cold for the spacecraft to continue to function.

Yet it appears to have survived the deep freeze. On 25 February, the official SLIM account on X (formerly Twitter) posted that a signal had briefly been received from the lander, stating: "As it was still midday on the moon, the temperature of the communication equipment was extremely high, so communication was terminated after only a short period of time."

"The batteries will attempt to keep Odysseus warm and alive, but eventually it'll fall into a deep cold"

As the day wanes over the SLIM lander, its operators will try once again to establish communication. If this works, it may lend some hope that the Odysseus lander could survive lunar night as well. With 10 missions planned for the moon's south pole this year, that hope is much needed. ▮

Mind

We finally know why live music makes us so emotional

HEARING live music may be more stirring than listening to a recording of the same tune because it triggers greater activity in the part of the brain linked to processing emotions.

Sascha Frühholz at the University of Zurich in Switzerland and his colleagues composed 12 pieces of music, each lasting 30 seconds. Half were written with the aim of conveying negative emotions, such as sadness and anger. These were slower, less harmonious and included more minor chords than the remaining songs, written to evoke positive emotions.

The researchers then recruited 27 people, who weren't musically trained, to listen to these 12 pieces twice – once performed by a live pianist, which the participants heard through a speaker, and once as a recording. The order they listened to them was randomly assigned, with 30 seconds of silence in between. People didn't know when they were hearing a recording or live music.

While listening to the music, the participants lay in an MRI scanner so the team could monitor their brain activity. The pianist then adapted the volume and speed of the piece according to the brain activity. For example, if someone was showing little activity in response to a positive piece of music, the pianist might play louder.

MATT CROSSICK/ALAMY

Performers like Elton John, pictured at Glastonbury Festival 2023, adapt to the crowd

"Recorded music is not adaptive to how a listener is responding, but live pianists often adapt the music to the audience to get the best response from them," says Frühholz.

Live performances of both the negative and positive pieces led to increased brain activity in the left amygdala, the region of the brain that is strongly linked to assigning sensory stimuli, such as sounds, to certain emotions.

The recorded tunes sparked much less, and more inconsistent, activity in the left amygdala. This matched how emotive the participants rated each piece of music after the experiment (*PNAS*, doi.org/mh7h).

The findings show that live music intensifies our emotional response, probably due to its free-flowing, dynamic nature, says Frühholz. ▮

Chen Ly

Geometry

Mathematicians discover 'soft cell' shapes behind the natural world

Alex Wilkins

TETRA IMAGES/ALAMY

A NEW class of mathematical shapes called soft cells can be used to describe how many patterns in living organisms – such as muscle cells and nautilus shells – form and grow.

Mathematicians have long studied how tiles fit together and cover surfaces, but they have largely focused on simple shapes that fit without gaps, such as squares and triangles.

It is rare, however, for nature to use perfectly straight lines and sharp points. Some natural objects are similar enough to straight-edged tiles, known as polyhedrons, that they can be described by polyhedral models, such as a collection of bubbles in a foam or the cracked surface of Mars. But some curved shapes, such as three-dimensional polygons found in the epithelial cells that tile the lining of blood vessels and organs, are harder to describe.

Now, Gábor Domokos at the Budapest University of Technology, Hungary, and his colleagues have discovered a class of shapes that describe tilings with curved edges, which they call soft cells. The key to these shapes is that they contain as few sharp corners as possible, while also fitting together as snugly as they can.

"These shapes emerge in art, but also in biology," says Domokos. "If you look at sections of muscle tissue, you'll see the cells having just two sharp corners, which is one less than the triangle – it is a very special kind of tiling."

In two dimensions, soft cells have just two sharp points connected by curved edges and can take on an infinite number of different forms. But in three dimensions, these shapes have no sharp points, or corners, at all. It isn't obvious how many of these 3D soft cells, which Domokos and his team call z-cells, there might be or how to easily make them, he says.

After defining soft cells mathematically, Domokos and his team looked for examples in the real world and discovered they were widespread. "We found that architects have found these kinds of shapes intuitively when they wanted to

"The key to these shapes is that they have as few corners as possible, while also fitting snugly"

avoid corners," says Domokos. They also found that z-cells were common in biological processes that grow from the tip of an object, like in algae filaments.

One of the clearest examples of z-cells is in seashells made from multiple chambers, such as the nautilus shell, which fascinates mathematicians as its structure follows a logarithmic pattern (arXiv, doi.org/mh3v).

The chambers within nautilus shells are an example of soft cells

The two-dimensional slices of each of the shell's chambers looked like a soft cell, so the researchers examined nautilus shells with a CT scanner to measure the chambers in three dimensions. "We saw no corners," says Domokos, which suggested the chambers were like the z-cells they had described mathematically.

"They've come up with a language for describing cellular materials that might be more physically realistic than the strict polyhedral model that mathematicians have been playing with for millennia," says Chaim Goodman-Strauss at the University of Arkansas. These models could improve our understanding of how the geometry of biological systems, like in soft tissues, affects their material properties, he says. ▮

Technology

AI can tell where a mouse is by reading its brain signals

James Woodford

ANALYSING a mouse's brain activity can reveal where the animal is and the exact direction it is looking in.

Mammalian brains use two main types of neurons for navigation: head direction cells show where an animal is facing and grid cells help provide a two-dimensional brain map of where it is located.

To learn more about the firing of these neurons, Vasileios Maroulas at the University of Tennessee, Knoxville, and his colleagues analysed data from a previous study. In that experiment, probes were inserted into mouse brains. Data on their neural firing patterns was then paired with video footage showing their locations and head positions as they moved around an open environment.

From this, Maroulas and his colleagues developed an artificial intelligence algorithm that can use neural activity to work out where a mouse is looking and where it is located (*Biophysical Journal*, doi.org/mh3w).

It is a bit like the drop pin and directional arrow on the map app of a smartphone, except instead of linking to a GPS satellite, you can analyse a subject's brain signals, say the researchers.

"This method allows us to not be dependent on a preloaded map or updating the GPS coordinates based on, say, satellite data," says Maroulas.

"In some sense, the algorithm 'thinks' and recognises space as a mammalian brain would," he says. "In other words, we take advantage of how the mammalian brain processes data and incorporate it in the architecture of the algorithm."

The AI could eventually enable intelligent systems to navigate autonomously, says Maroulas, by helping them know where they were and which direction they are facing. ▮

Physics

Quantum engine driven by single atom

A tiny piston could power nanosized devices or help control how they heat up

Karmela Padavic-Callaghan

A SINGLE atom inside a reflective cavity could drive a piston in a tiny, quantum version of an engine.

The essential feature of any engine is that it converts heat into work, which can then set mechanical parts into motion. For internal combustion engines, burning a fuel makes gas expand and push on pistons, which eventually results in car wheels or turbine blades moving. Álvaro Tejero and his colleagues at the University of Granada in Spain have now designed a similar engine for the quantum realm.

"You can imagine keeping a classical piston but replacing the classical gas with the simplest quantum system, which is one atom. That was our starting point," he says.

The atom and the piston in the quantum engine would sit inside a small cavity made from a reflective material, like a tiny box made of mirrors. The piston would be a solid microscopic object made of a similar reflective material. In a conventional engine, the piston moves because it gets repeatedly hit by many gas atoms, but here its motion would come from quantum radiation.

This could happen a few different ways. If the atom warms up or gains energy from the engine's environment in some other way, such as by being illuminated, it would release the energy as radiation that would then get stuck bouncing within the reflective cavity and repeatedly interact with the atom. Additional energy would cause more radiation to build up and its pressure would move the piston.

Alternatively, the cavity could warm up and start to radiate, and that radiation would again bounce off the walls and interact with the atom. The research will be published in *Physical Review E*.

Quantum engines have been modelled and built in experiments before, says team member Daniel Manzano, but rigorous proof that they could produce useful mechanical work

"Imagine a classical piston but replace the gas with the simplest quantum system – one atom"

has been lacking. The researchers calculated that not only would their engine work, but it would produce two crucial sequences of piston motions that happen in engines, known as the Otto cycle and the Carnot cycle.

Pablo Hurtado, also part of the team, says some of these results were surprising as the quantum world of single atoms and small objects is so different from the world in which much larger conventional engines exist that even seemingly simple ideas like defining work or temperature aren't a given.

It is challenging to get such a clear mathematical understanding of the notions of heat or work at the quantum level, says Dario Poletti at the Singapore University of Technology and Design. The new findings could be useful for building nanosized devices or controlling how they heat up, which is crucial for many emerging quantum technologies such as computing and communications.

The fact that this engine design relies on solid materials rather than the gases of very cold atoms used in some past studies could also inspire many new experiments, says Poletti. ▮

Animals

Jackals may urinate on their favourite fruit to deter thieves

BLACK-BACKED jackals urinate on sweet melons that grow in the Namib desert, seemingly to stop other jackals pinching the fruit as it ripens.

The jackals, which are native to eastern and southern Africa, hunt small prey or scavenge on the carcasses left by larger predators, but they are also partial to fruit.

Jeremy Midgley at the University of Cape Town, South Africa, and his colleagues set up camera traps to study the role that black-backed jackals (*Canis mesomelas*) play in spreading the seeds of the !nara plant (*Acanthosicyos horridus*).

The melon-like !nara fruit has sweet and juicy flesh and can weigh up to a kilogram each. Jackals have the jaws to chew through the fruit's tough skin and, crucially, the noses to find it.

"Our research has shown they are highly motivated to locate, choose and consume !nara," says Midgley. "We obtained so many videos of jackals visiting !nara plants and fruit that it is clearly not an opportunistic feeding strategy."

SAIMA SHIKESHO

Camera traps recorded black-backed jackals feeding on !nara fruit in the Namib desert

During the experiments, the research team buried 55 melons, both ripe and unripe, in the sand up to 100 metres away from !nara plants. Jackals found all of them (*Journal of Zoology*, doi.org/mhq8).

Jackals would sometimes partially excavate the fruit, urinate on them and then leave them for a few days before retrieving them. By urinating on the fruit, the jackals may be trying to declare ownership or to mask their smell as the fruit ripens, thereby denying other jackals the chance to track them down, says Midgley.

The jackals produced droppings filled with undamaged seeds. The team found these seeds germinated more successfully than those extracted directly from ripe fruit.

"It has long been known that carnivores may consume fruit, such as bears eating berries, but there has been little evidence of carnivores being primary [seed] dispersers," says Midgley. ▮

Ryan Truscott

Astronomy

Huge set of galaxies set to form largest known cluster

Alex Wilkins

ONE of the largest quasars in the early universe has helped to reveal a vast "protocluster" of nascent galaxies that is expected to grow more massive than any galaxy cluster we know of.

Protoclusters are the primordial beginnings of the galaxy clusters we see in our region of the universe, before they are bound together by gravity. Astronomers usually look for them by casting their telescopes over wide swathes of space, hoping to find regions with an unusually high number of early galaxies.

Instead, Feige Wang at the University of Arizona and his colleagues decided to focus their attention on a quasar, a luminous galactic core where gases emit light as they fall into a supermassive black hole. They chose one of the brightest and most massive quasars known in the early universe, whose light is only now reaching us from 800 million years after the big bang, hoping it would act as a signpost for other massive objects around it.

They found a vast web of early galaxies surrounding the quasar. The protocluster is expected to grow over time and eventually collapse into a galaxy cluster. Once this happens, Wang and his team calculate it will have a combined mass around 7 quadrillion times that of the sun, potentially bigger than the largest known galaxy cluster in our region of the universe (arXiv, doi.org/mhqr).

The quasar at the centre of the cluster is probably a supermassive black hole with a mass about 3 billion times that of the sun. It is difficult to explain how this black hole grew so massive in such a short time after the birth of the universe, says Wang, but finding systems similar to this could help shed light on the problem, as well as on how such massive quasars affect nearby galaxies. ▮

Health

Pet dogs of various breeds can sniff out Parkinson's disease

David Cox

WE HAVE long known that dogs are capable of using their noses to detect certain types of cancer, malaria and even covid-19. But these medical-detection animals tend to be made up of just a few breeds, raised in expensive training centres. Now, research has shown that pet dogs of various breeds can be trained to identify the unique scents linked to Parkinson's disease with nearly 90 per cent accuracy.

A dog's sense of smell can be up to 100,000 times more acute than people's. Those with conditions such as Parkinson's disease produce hundreds of specific chemicals in their sebum, the oily substance that hydrates the skin. With Parkinson's having no set diagnostic test, the animals have been suggested as an alternate approach to speed up access to treatment.

The breeds studied for medical detection typically include Labrador retrievers as well as different types of shepherd dogs.

Dogs can often detect skin chemicals related to health conditions

SOLSTOCK/GETTY IMAGES

Seeking a broader, inexpensive approach, Lisa Holt and Samuel Johnston at the charity PADs for Parkinson's in Washington state recruited 23 pet dogs of 16 breeds. These included breeds that have previously been used to detect different medical conditions, as well as those that generally aren't raised for this purpose, such as Pomeranians and English mastiffs.

86%

The accuracy of tested dogs at detecting Parkinson's disease

Forty-three people who had been diagnosed with Parkinson's disease and 31 volunteers with no known medical conditions provided sebum samples, either via T-shirts worn overnight or swabs of their upper backs.

Each dog was put through a training programme lasting at least eight months. They were trained to communicate when they identified a Parkinson's sample by sitting, barking, tapping a paw or bobbing their nose. To incentivise them, each sniffing sample provided by a participant with Parkinson's disease was paired with a reward, such as food or a toy.

Once their training was complete, the dogs were exposed to sebum samples they hadn't previously encountered. Their owners didn't know whether the samples were from someone with or without Parkinson's.

Overall, the dogs identified the samples from someone with Parkinson's disease with 86 per cent accuracy, on average, and didn't respond to the healthy volunteers' samples 89 per cent of the time (bioRxiv, doi.org/mhp9).

Testing of the training programme is continuing at the Alfort National Veterinary School in France, says Holt. "Once that training was done, it would then be possible to test whether dogs could identify Parkinson's at a much earlier stage, when the full suite of symptoms are not yet present," she says. The researchers hope that the odorants relating to Parkinson's disease could one day be packaged into a training aid for dogs.

"Many dog studies for disease detection are proof of principle, with just two dogs, for example," says Nicola Rooney at the University of Bristol, UK. "This study shows training can be successful with a variety of home-housed dogs."

However, despite testing several breeds, the dataset isn't large enough to conclude which ones detect Parkinson's disease best, she says. ▮

Environment

Death Valley has a lake – for now

The normally ultra-dry basin has experienced heavy rain

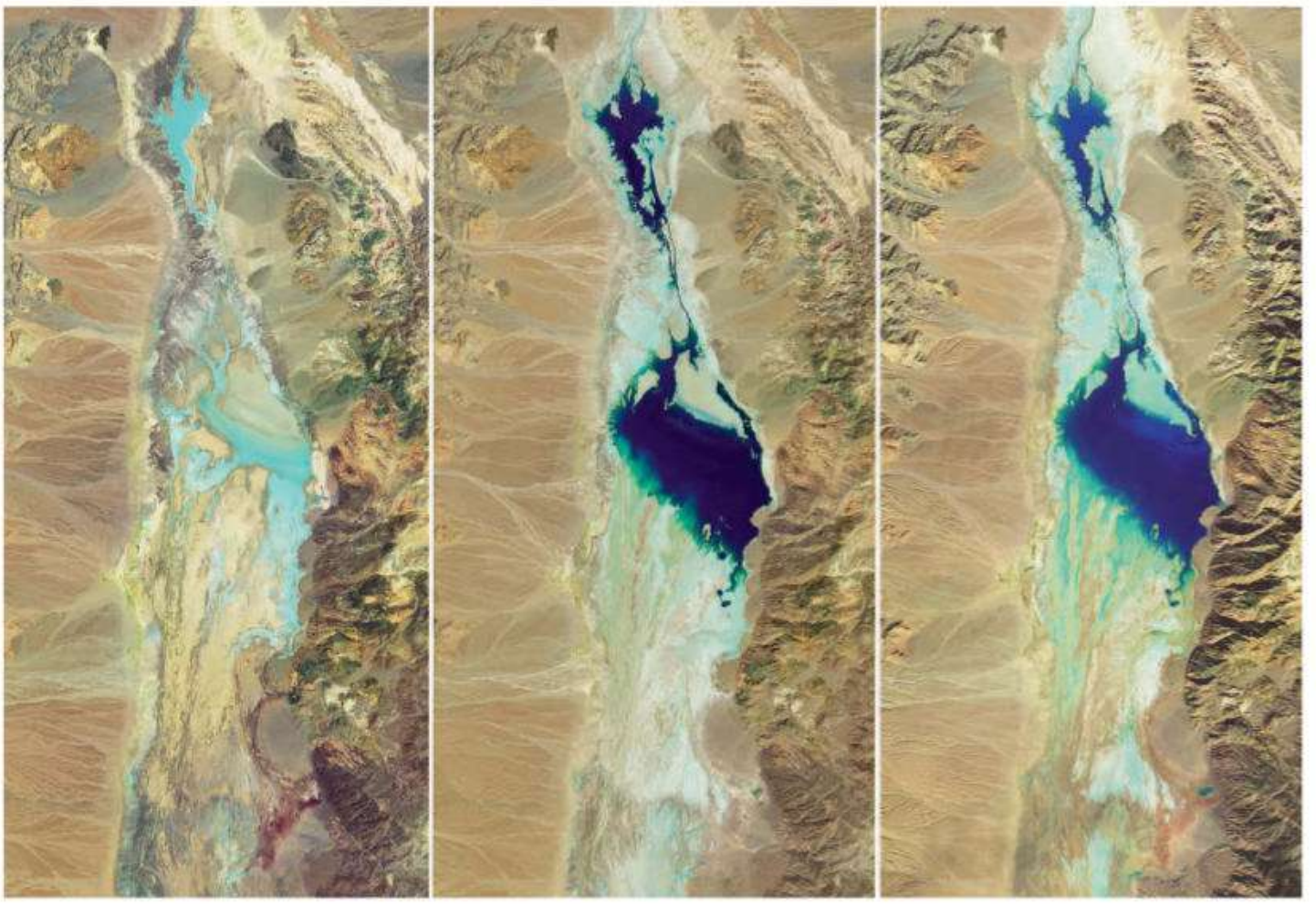
Chen Ly

CALIFORNIA has had heavy rainfall in recent weeks, causing a rare, temporary lake to form in Death Valley – the driest place in the US.

Atmospheric rivers – narrow strips of intensely concentrated moisture in the air – over California have exacerbated the wet conditions, leaving up to 37 million people at risk of flooding.

Death Valley National Park sits along the border of California and Nevada, where so much rain has fallen that the park's Badwater basin, usually a dry salt flat (immediate right), has been turned temporarily into a shallow lake (far right), which measures nearly 10 kilometres at its longest and is around 0.3 metres deep.

An even bigger lake formed in August 2023 (middle right) after rainfall associated with Hurricane Hilary. It shrank over the next few months, before the recent rains refilled it. ▮



NASA EARTH OBSERVATORY/WANMEI LIANG; LANDSAT/U.S. GEOLOGICAL SURVEY

Physics

Tiny magnet could probe quantum gravity

A DEVICE that can measure the gravitational force on a particle lighter than a grain of pollen could help us understand how gravity works in the quantum world.

Despite keeping you stuck to the ground, gravity is the weakest force we know of. Only very large objects, like planets and stars, produce enough gravitational force to be easily measured. Doing the same for very small objects on the tiny distances and masses of the quantum realm is extremely difficult, in part because of the minuscule size of the force, but also because larger objects nearby can overwhelm the signal.

Now, Hendrik Ulbricht at the University of Southampton in the UK and his colleagues have developed a new way to measure gravity on small scales by using a tiny neodymium magnet weighing around 0.5 milligrams, that is levitated by a magnetic field to counteract Earth's gravity.

Tiny changes in the magnetic field of the magnet created by the gravitational influence of nearby objects can then be converted into a measure of the gravitational force. The whole set-up is cooled to almost absolute zero and suspended in a system of springs to minimise outsides forces.

The probe can measure the gravitational tug of objects that weigh just a few micrograms. Ulbricht and his team found that, with a 1-kilogram test mass spinning nearby, they could measure a force on the particle of 30 attonewtons (a billionth of a billionth of a newton). One limitation is that the test mass must be in motion at the right speed to create a gravitational resonance with the magnet, otherwise the force won't be strong enough to be picked up (*Science Advances*, doi.org/mh3q).

The next stage of the experiment will be to shrink the test mass to a similar size as the magnetic particle, so that gravity can be tested while the particles are showing quantum effects like entanglement or superposition. This will be difficult, says Ulbricht, as such small masses will require all other parts of the experiment to be incredibly precise, such as the exact distance between the two particles. Getting to this stage could take at least a decade.

"The fact that they even tried this measurement I find mind-boggling," says Julian Stirling, a UK-based engineer, due to the difficulty in isolating other gravitational effects. The researchers will need to figure out how to minimise the gravitational influence of the anti-vibrational system, says Stirling, because it seems to have exerted a small but noticeable effect on the levitated particle in this experiment. ▮

Alex Wilkins

Physiology

Forgotten body part may affect fertility

An appendage of the ovaries dismissed as having no purpose might actually help control ovulation and the menopause, finds **Michael Le Page**

A KEY component of the female reproductive system may have been overlooked. Research into the rete ovarii, an appendage of the ovaries that has previously been dismissed as useless, suggests it has an important role after all.

"We think it is regulating the timing or rate of ovulation," says Blanche Capel at Duke University in North Carolina. "It may control how many [ovarian] follicles are activated in one's cycle or when they are activated."

Her team plans to do further studies to try to confirm this. "We haven't proved all of this, but there are several smoking guns here," she says.

Capel and her colleagues came across the structure in 2022 while creating 3D images of developing mouse ovaries and surrounding material.

KATERYNA KON/SPL/GETTY

Next to each ovary (the oval-shaped object above) is a tiny structure called the rete ovarii (not clearly visible here and generally too small to see easily)

Mystery structure

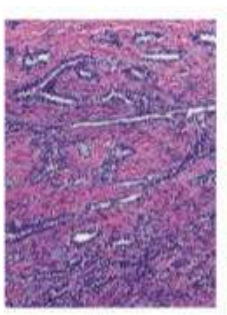
These images are created by using fluorescent antibodies to light up specific tissues. When the team used one that binds to a protein called PAX8, it showed up a tubular structure next to each of the ovaries, extending into them.

"When we first found it, we thought, 'what is this?'," says Capel. It turned out to be the rete ovarii, a structure that was first described in 1870, says team member Dilara Anbarci, also at Duke University. It seems to be common to all mammals and was included in the 1914 edition of *Gray's Anatomy*, a standard medical textbook on the human body.

But much of the attention the rete ovarii has received is related to rare abnormalities, such as cysts and tumours. With some studies concluding it is a vestigial structure with no function, it has been dropped from modern editions of the book.

1870

The year the rete ovarii structure was first described



ZIAD M. EL-ZAATARI/SPL

A microscope image of a slice of a rete ovarii reveals net-like glands (stained blue) inside

Part of the problem is that even in large animals, the rete ovarii is extremely difficult to see with the naked eye, says Anbarci. It is only because the team was creating 3D images with PAX8 that it could be seen in mice, she says. "It was just the luck of using the right antibody."

While continuing to study the development, structure and function of the rete ovarii, mostly in mice, the researchers found nerves connecting to the appendage (bioRxiv, doi.org/mhnb). Anbarci is now trying to establish if these are sending information or receiving it.

In another experiment, Anbarci injected a fluorescent dye into the part of the rete ovarii furthest from the ovaries, finding that this substance was carried all the way to the organ to which it is attached.

"So it can actively transport fluid into the ovary," says Capel. "That suggests that it really does function. It's also surrounded by macrophages, which are really interesting cells that communicate a lot around the body."

We know the ovaries respond to what is happening elsewhere in the body. Extreme exercise can halt ovulation, while obesity can result in irregular ovulation, for instance.

"It may be a sensory mechanism for the ovary to keep tabs on the rest of the body"

It is assumed that the ovaries respond directly to chemical signals in the blood, but it could be the rete ovarii that is relaying signals, says Capel. "It may be a sensory mechanism for the ovary to keep tabs on what's going on in the rest of the body," she says. "Kind of like an antenna."

Extending fertility

If this is true, it might also play a role in determining when the menopause occurs, says Capel. "If it plays a role in regulating the number of follicles that are ovulated, it could be regulating the female reproductive lifespan," she says. "So we could perhaps use it somehow to extend the female reproductive lifespan."

In the latest study, the researchers call for the rete ovarii to be added to the list of structures that make up the female reproductive tract – along with the vulva, vagina, cervix, uterus, oviduct and ovaries – and for its role to be examined further.

There is a related structure in the testes that is called the rete testis, but the team says its research shows the rete ovarii is more complex.

Silvia Garagna at the University of Pavia in Italy says the role of the appendage is worth exploring. "Capel's hypothesis is quite reasonable and merits investigation," she says. ▮

Social media

LGBTQ people seen as needing more protection online than Christians

Chris Stokel-Walker

PUBLIC appetite for moderating toxic speech on social media depends on who is being targeted, researchers have found, with billionaires being seen as in least need of protection.

Content moderation is a hot-button issue, with social media platforms taking very different approaches. Elon Musk bought Twitter, since renamed X, in part because of his concern about over-moderation infringing the right to free speech. Others feel platforms don't do enough to protect users from hate and harm.

But perceptions differ wildly. "When it comes to toxic online speech, it actually matters who is targeted," says Franziska Pradel at the Technical University of Munich, Germany.

Pradel and her colleagues asked about 9000 US adults to read social media posts directed at three user profiles: a billionaire, a member of the LGBTQ community and a Christian truck driver. Participants saw some posts simply disagreeing with a user, while others attacked the same user using uncivil, intolerant or threatening language, collectively known as toxic speech.

The team asked people how they thought a social media platform should respond to each post, with the options including doing nothing, removing the post, suspending the person's account, placing a warning label on the post or reducing its visibility.

Generally, about 10 per cent of participants recommended action against argumentative but non-toxic posts, which jumped to around 30 per cent for uncivil or intolerant language and over 50 per cent for threatening posts.

However, opinions on taking action varied depending on who was being singled out. In all, 58 per cent agreed that posts attacking an LGBTQ person should be removed, compared with 36 per cent for posts targeting a Christian truck driver and 21 per cent for those against a billionaire (*American Political Science Review*, doi.org/mdrp).

"It shows us that it might be that when someone is not perceived as a protected group, then users may be less likely to demand moderation," says Pradel.

One limitation of the study is that the participants skewed younger, better educated and more likely to be Democrats than the general US population, although Pradel says this also reflects the demographics of social media users. Participants who were Democrats were also more likely than Republicans to demand that action of some sort was taken against harmful posts.

Carolina Are at Northumbria University, UK, welcomes the fact that LGBTQ hate warranted more moderation than attacks on other groups, but is concerned that so few participants felt the platforms ought to deal with hate speech, with the majority favouring no action. This is despite laws in many nations requiring platforms to actively police hate speech.

"Something the study captures inadvertently is the passivity and almost defeatism of general audiences when it comes to platform power," she says, so it will take a lot to galvanise people to hold platforms to account. ▮

ROBERT K. CHIN/ALAMY

The Progress Pride Flag represents marginalised LGBTQ communities

Botany

Deadly plant kills its pollinators but nurses their young

JACK-IN-THE-PULPIT flowers, which trap and kill their pollinators, might also serve as a nursery for the insects' eggs, revealing a more nuanced and mutually beneficial relationship.

These pitcher-shaped plants of the genus *Arisaema* lure in their primary pollinators, fungus gnats, by mimicking the looks and scent of musty mushrooms. But once an insect dips into a flower's spathe in pursuit of this pungent treat, it can't crawl out because the flower's elongated hood interior is too waxy. The gnat jostles and struggles inside the mottled, reddish-green cup, spreading pollen around, but it eventually tires itself to death.

At least this is what botanists have long thought.

But when Kenji Suetsugu and his team at Kobe University in Japan incubated 62 flowers of the Asian jack-in-the-pulpit species *Arisaema thunbergii*, they noticed that the trapped gnats laid their eggs in the flowers' crowns. When the flowers began dying, hatched larvae fed on their shrivelling flesh and popped out as adults a few weeks later (*Plants, People, Planet*, doi.org/mhnd).

The fact that the traps could serve a dual function – as a site of pollination and as a nursery for the next generation of pollinators – is surprising, says Suetsugu.

"When the flowers began dying, hatched larvae fed on their shrivelling flesh"

Plus, some adult gnats do manage to escape the flower traps before it is too late, meaning the dupe isn't strictly lethal, he says. This suggests the plants are striking a balance between ensuring they get pollinated and not wiping out the population of pollinating gnats.

These findings suggest the relationship between jack-in-the-pulpits and their pollinators is much more complex than previously thought, and "cannot be neatly categorised as purely mutualistic or antagonistic", says Suetsugu. ▮

Sofia Quaglia

Space

Martian soil could be turned into fibres as strong as steel

Chen Ly

THE soil on the Red Planet could be melted down, spun into fibres that are as strong as steel and used to make durable building materials for a potential Martian base.

Instead of sending vast amounts of resources to Mars to build a colony there, which would be very costly, researchers are exploring the idea of making materials using what would be available on site.

"We wanted to see if we could use Mars soil to develop fibre materials," says Peng-Cheng Ma at the Xinjiang Technical Institute of Physics and Chemistry in China. "Fibre has lots of functionality, for clothing or fibre-based material."

To do that, Ma and his colleagues recreated Martian basaltic soil, which is largely made up of silica with traces of aluminium oxide, iron oxides, magnesium oxides and calcium oxide.

They heated the proxy soil to 1500°C and then submerged it in water to cool it down. Next, they crushed the material and fed it into a spinning machine to form fibres.

The diameters of the fibres ranged from 9.7 to 13.9 micrometres, and they had a maximum tensile strength of 1320 megapascals, which means they could withstand a similar amount of stress as a small steel bar (arXiv, doi.org/mhnm).

"It's quite similar to typical glass fibre used in the reinforcement of concrete," says Ma.

As well as being useful for building, the fibre could be used as a medium to grow plants in, since it holds water better than the dry Martian soil, he says. Or it could be used to make clothes, like T-shirts for astronauts, on Mars.

The fibre-forming process may be affected by conditions on the Red Planet though, such as the lower gravity, says Ma, who hopes to refine the process to better suit the Martian environment. ▮

Earth

Volcanic eruption 7300 years ago was record-breakingly huge

Alex Wilkins

THE largest volcanic eruption of the current geological epoch happened underwater off the southern coast of what is now Japan about 7300 years ago. The blast produced more than three times as much material as the largest modern eruption known, that of Mount Tambora, which exploded in Indonesia in 1815 and caused such drastic climate changes that it led to the "Year Without a Summer" in 1816.

The new record-holder, the Kikai-Akahoya eruption, came from a submerged caldera in a region of sea near the Japanese island of Kyushu.

The eruption's devastating consequences for humans living on nearby islands have been documented by geologists and archaeologists. Analysis of deposits of volcanic ash had indicated that the blast was one of the largest eruptions of the current geological epoch, the Holocene, which began 11,700 years ago.

However, the blast's origins and size were uncertain because of the difficulty in accessing the undersea caldera, the crater that formed after the volcano erupted.

Now, Nobukazu Seama at Kobe University in Japan and his colleagues have calculated that the Kikai-Akahoya eruption produced a far larger amount of rock and ash underwater than previously thought, at around 70 cubic kilometres. Combining this with previous estimates from volcanic rock deposited over Japan, the total amount of material pumped out by the volcano equates to more than 300 cubic kilometres of debris.

"It is quite big, more than we expected," says Seama.

It is still way behind the massive eruption of the Toba supervolcano in Indonesia some 74,000 years ago, though, which released more than 2500 cubic kilometres of magma.

300km³

Volume of material ejected by the Kikai-Akahoya volcano

To assess Kikai-Akahoya, Seama and his colleagues did a seismic survey to map out the underwater region around the caldera roughly 200 metres below the surface. From this, they could see the layers of material around the volcano, but they didn't know which were from the eruption itself.

So the researchers collected deposits from the sea floor using a remote-controlled drilling robot and took core samples from the rock below, identifying a layer that contained distinctive volcanic glass. This allowed them to isolate the volcanic layer from the seismic survey and calculate the volume of material ejected (*Journal of Volcanology and Geothermal Research*, doi.org/mhdq).

"We know that these very large, caldera-forming eruptions are rare, but we also know that there are more of these events in the geological past that we've found evidence for," says David Pyle at the University of Oxford.

The Kikai-Akahoya caldera still has a big magma chamber underneath it. While the chances of it erupting are small, says Seama, his team is working on measuring the chamber more accurately to improve our understanding of the risk.

Combining information from past eruptions like Kikai-Akahoya with studies of more recent underwater eruptions, such as the Hunga Tonga eruption in 2022, could help us produce better models for predicting future eruptions, says Pyle. ▮

Iōjima Island sits at the edge of the underwater Kikai-Akahoya caldera

THE ASAHI SHIMBUN VIA GETTY IMAGES

Medicine

Fast response eases Crohn's symptoms

TAKING the drug infliximab straight after a Crohn's diagnosis improves outcomes, despite this not being the usual practice.

Miles Parkes at the University of Cambridge and his colleagues recruited 386 people in the UK aged between 16 and 80, all newly diagnosed with the inflammatory bowel condition Crohn's disease.

One group was treated with standard medications. If their symptoms persisted or worsened, these people were also prescribed the antibody drug infliximab. A second group received infliximab immediately, regardless of symptoms. After a year, 80 per cent of the latter group had controlled their symptoms, compared with 15 per cent of those who didn't get the drug immediately (*The Lancet Gastroenterology & Hepatology*, doi.org/mhnv). **Chen Ly**

TONY WU/NATURE PICTURE LIBRARY/ALAMY

Astrophysics

Supernova has a neutron star inside

NEARBY supernova 1987A has a hot neutron star at its centre.

There are two possible objects that can be left behind after a star explodes in a supernova: a neutron star, which is a dense stellar corpse made primarily of neutrons, and a black hole. To determine which was at the centre of supernova 1987A, Michael Barlow at University College London and his colleagues used the James Webb Space Telescope to examine its remains.

They found a telltale pattern in the wavelengths of light in which the supernova was particularly bright. The wavelengths and the areas the light shines from indicate that it is being caused by powerful radiation (*Science*, doi.org/mhnx). "It's got to be radiation from a hot source, and the only possible hot source is a neutron star," says Barlow. **Leah Crane**

Marine biology

Whales have a special larynx for singing underwater

WE NOW know how baleen whales produce their songs – and it involves their uniquely shaped larynx.

Baleen whales, including humpbacks, communicate with complex songs that can be heard over vast distances. To find out how they do this, Coen Elemans at the University of Southern Denmark and his colleagues extracted the larynxes of three recently deceased baleen whales: a sei whale (*Balaenoptera borealis*), a humpback whale (*Megaptera novaeangliae*, pictured above) and a northern minke whale (*Balaenoptera acutorostrata*).

The larynx, commonly known as the voice box, sits at the top of the neck in mammals. When air flows through this organ, folds of tissue vibrate, resulting in sound.

But that isn't the case with baleen whales, says Elemans. The team found that the whales' larynxes had an unexpected shape, with a cushion of fat on one side of the organ.

As these whales breathe, air is pushed against the fatty material, making it vibrate and produce sound. "We've never seen this in any other animal," says Elemans. "It's totally unique to baleen whales."

The whales can also recycle the air in their lungs, which is useful when they are submerged for long periods of time. When they breathe out through their windpipe and larynx, the air goes into a sac with a contracting wall that expels it back into their lungs (*Nature*, doi.org/mhnt).

From a computer model of the larynx, the team found that baleen whales could produce frequencies up to 300 Hertz at a maximum depth of 100 metres below the surface of the sea. CL

Really brief

MATT BRADY/THE UNIVERSITY OF TEXAS AT EL PASO

Punk bird reappears after 20 years

A rare bird with a stunning yellow crest has been photographed for the first time – almost two decades after the last confirmed sighting. The yellow-crested helmetshrike (*Prionops alberti*), with its black plumage and mohawk-like golden crest, was seen in the Democratic Republic of the Congo.

Robot dog opens doors with its leg

A robot dog can use a leg to press buttons, open doors and pick up rucksacks while balancing on its other three legs. The ANYmal robot, made by ANYbotics, was trained using a machine-learning model that worked out how to control the remaining three legs to balance the robot (arXiv, doi.org/mhns).

Water battery floats closer to viability

Batteries based on water could soon be a commercial reality. Previous water batteries would lose half of their capacity after 500 charging cycles, but a new one only loses 15 per cent because its anode and cathode are coated in a metal compound called bismuth oxide (*Advanced Materials*, doi.org/mhn2).

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Views

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Culture columnist
Simon Ings on a film exploring what is worth keeping p30

Comment

The scent of music

Smell has unrivalled emotional power. As such, the art of olfaction is rightfully taking its place in a new multisensory performance, says perfumer **Mathilde Laurent**

WHAT would our understanding of music be like if composers had routinely created works for scent as well as sound? At the turn of the 20th century, artists were combining the senses to imagine "total" artworks. Visual artist Wassily Kandinsky was painting the music he experienced, while composer Alexander Scriabin was adding directions for coloured lighting in his 1910 score for *Prometheus: The Poem of Fire* – a work I have been collaborating on with the San Francisco Symphony.

In dialogue with the orchestra's music director, Esa-Pekka Salonen, and piano soloist, Jean-Yves Thibaudet, we discussed the idea that Scriabin was unable to compose for olfaction because engineering and technology in his day couldn't deliver it. It has been our goal to add a curated scent experience to his visionary piece and to provoke a discussion – why shouldn't perfumery take its place alongside other arts?

Over a number of years, I have been exploring scent in settings we at Cartier have named "unidentified scented objects", where perfume is freed from simply being a product and presented to the public beyond any commercial context. In such scenarios, we can show that smell is an unrivalled vector of emotions.

As I came to *Prometheus*, which tells the myth of how humanity was gifted fire, I was reminded of the ceremonial origins of perfumery: the word "perfume" (from the Latin *per fumum* or "through smoke") comes from sacred rituals involving fire to obtain scent. It used to be said that the wrath of the gods was in their noses, and so diffusing pleasant scents would calm them.

ADRIÀ VOLTÀ

My task with *Prometheus* is to ensure that, as the music unfolds, the scent stirs a primal, universal and instinctive emotion, far removed from any aesthetic aim. I investigated data that linked perfumery ingredients with emotions. I want to bolster and consolidate the feelings instilled by the music, by focusing – through olfaction – on the ancestral instinct of every spectator, to get them to engage emotionally and physically with the music without ever overshadowing its aesthetic.

I particularly focus on smell being a sense that directly stimulates the instinctual centre and the limbic brain, the amygdala, and which stimulates memories and emotions via the hippocampus. Olfaction bypasses our reason. When we smell, the activities of our cerebral zones are modified and uninhibited. My aim is to show this potential of olfaction and the merging of senses. In this project, olfaction dramatically increases the music's emotional potential. Through listening to and discussing the piece with Thibaudet and Salonen, we identified three different sequences in which symbolic moments could be olfactory.

We set about addressing the problem that made scent curation impossible for Scriabin: the amount of time that one scent lingers in an enclosed space. Discreet devices strategically placed throughout Davies Symphony Hall, the home of the San Francisco Symphony, emit scent at key moments of the performance. The devices utilise a dry-air diffusion technique, where the air is propelled through capsules infused with fragrances.

Following Scriabin's vision, my goal is to create a state in which all the senses are solicited, and minds, hearts and even guts vibrate in unison. Like the artists at the turn of the previous century, we want everyone to experience the transcendence that art endows humanity. Olfactory art is as potent as any other art form in this regard. All our senses have a role to play. ▮

Mathilde Laurent is in-house perfumer at Cartier. *Prometheus: The Poem of Fire* is being performed by the San Francisco Symphony, 1 to 3 March

Artificially intelligent

Democracy in the chatbot age

We are beginning to see the tip of the iceberg when it comes to threats from chatbots. In a huge election year, how will AI affect upcoming votes, asks **Alex Wilkins**

Alex Wilkins is a *New Scientist* reporter covering artificial intelligence, physics and space. Artificially intelligent is a column that cuts through the hype and looks at what AI is really capable of and what it means for us. You can follow him @AlexWilkins22

Alex's week

What I'm reading
Wolf Hall *by Hilary Mantel. After she died in 2022, I resolved to read more of her work.*

What I'm watching
I've been rewatching The Matrix. *Some of it has held up well, and it feels relevant given the recent doom-filled prophecies of AI taking over the world.*

What I'm working on
I'm trying to learn what mathematics is really about – not a small task – for an upcoming feature.

This column appears monthly. Up next week: Chanda Prescod-Weinstein

THE biggest election year in the history of the world is under way, and we have just had our first glimpse at how artificial intelligence is being used by the shadowy world of government-backed hackers. These groups could have significant impacts on democratic processes through hacking, disinformation or leaking sensitive information. In February, Microsoft and OpenAI published a blog in which they identified groups affiliated with Russia, China, Iran and North Korea and detailed how they were using AIs like OpenAI's ChatGPT.

Good news, you might think. Crisis averted! But just as the veil has been slightly lifted, this new window onto chatbots' illicit uses could already be closing due to increasingly capable private and open-source large language models (LLMs). And even if it stays open, it remains to be seen whether identifying these threats will have any impact on preventing real-world harms.

The blog itself wasn't immediately alarming. One finding that Microsoft and OpenAI were quick to highlight is that there was no evidence of "significant attacks" orchestrated using their LLMs.

Instead, the companies produced a laundry list of smaller misdeeds, such as "LLM-informed reconnaissance", which means asking chatbots for help explaining complex, valuable technologies or security systems, specifically used by a Russian military-linked "actor" looking for satellite and radar information in the context of the Ukraine war.

They also found "LLM-supported social engineering", tricking people into giving away important information, used by a suspected North Korean outfit that was looking for help crafting convincing phishing campaigns – cyberattacks used to steal sensitive data like passwords. Programming tasks were also common, such as asking for help to develop computer viruses or finding ways to circumvent antivirus software.

According to Microsoft and OpenAI, this was all in line with their safety testing and predictions for how their systems might be misused, and they closed accounts associated with these groups. They also said they would continue monitoring their tools for further misuse. But there is a big issue here that didn't come up: the rapid rise of open-source AIs that can be run without access to the internet.

"We have seen how AIs can cause chaos for elections in Slovakia, the US and UK in the form of digital deepfakes"

One major reason why these companies were able to identify and catch these threats at all is because their technology, on the whole, is better than everyone else's, so they have a large user base. For many people, and that includes state-backed cybercriminals, there are some tasks that only ChatGPT can do.

But other companies and models are rapidly catching up. For many programming tasks, open-source AIs that people can tinker with and run on their own computers can do the job. Companies like French start-up Mistral and Meta's Llama models have proved surprisingly popular with people turned off by OpenAI's closed ecosystem, which people can't run on their own machines. And while running these models on local machines is a win for data privacy and experimentation, these models can be run offline, so are also far from the all-seeing eye of Microsoft's cybersecurity experts.

While Microsoft and OpenAI said their models didn't appear to have been used for significant attacks, the stakes are higher this year, when more than half the world's population, including India, the US and UK, will have the chance to vote for new governments. Already, we have seen how AI can cause chaos for elections in the form of digital deepfakes, affecting democracies in Slovakia, the US and the UK.

There are some obvious ways to mitigate against deepfakes, such as creating certificates of origin for online media, but protecting against the text-based tasks that LLMs deal with, like a fake email written to sound official, is trickier. Social engineering scams and operations rely on the fallibility of humans and certificates of origin can only go so far in these cases.

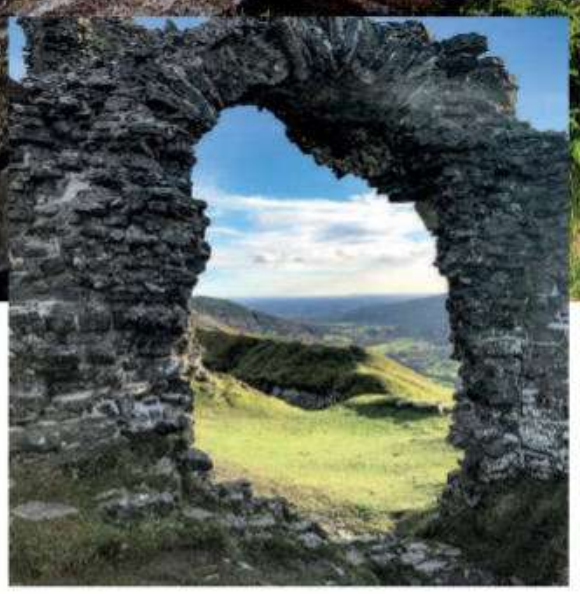
Some of the tasks found in Microsoft's blog specifically targeted potential mitigations too, like using LLMs to bypass security features such as two-factor authentication, which is often used to make sure only the right people can use sensitive online services.

Of course, Microsoft and OpenAI say they will continue to close accounts, track future threats and share what they find with the broader cybersecurity community. But the ease with which all these systems can be manipulated, and the enormous growth in availability and use of chatbots like ChatGPT, suggests it might be difficult to prevent these tools affecting the democratic process across the world. ▮

Discovery Tours

NewScientist

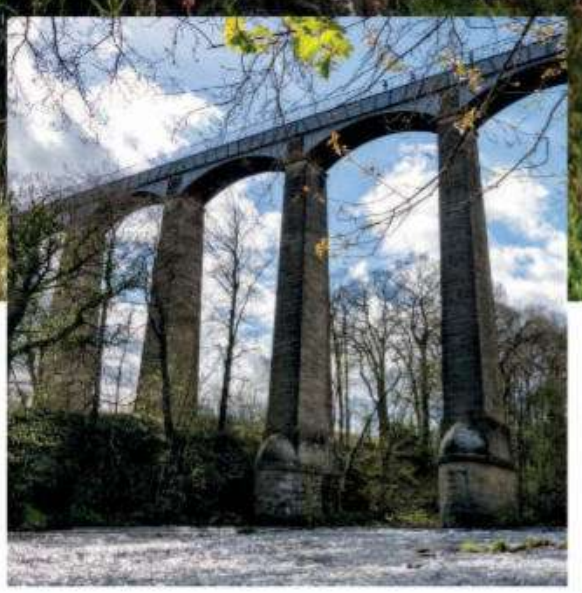
Looking to explore the UK this summer?



Retracing Charles Darwin's travels across North Wales

13 May 2024 | 6 days

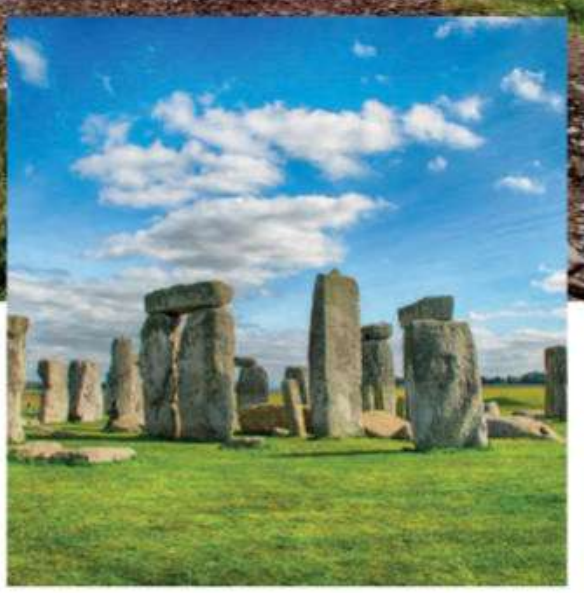
Uncover the best of Wales as you explore the dramatic Welsh landscapes of Eryri (Snowdonia) National Park and examine the regions geology and how it has been transformed by volcanic and glacial activity over the years. Discover the story of Charles Darwin's 1831 and 1842 tours of Wales, and retrace his travels on this small group journey to Shrewsbury and Snowdonia.



The science of the waterways: England and Wales

6 July 2024 | 7 days

Explore the science of the waterways of England and Wales while visiting six of the seven British wonders of the waterways, including Pontcysyllte Aqueduct, Standedge Tunnel and Bingley Five Rise Locks. Marvel at the engineering work and learn about the history of this 200-year-old network of canals that was originally built to transport industrial goods between towns and cities. Encounter locks, swing bridges, tunnels and aqueducts and explore quaint villages, insightful transport museums and majestic industrial heritage sites.



Human origins in prehistoric Southwest England

15 July 2024 | 5 days

Immerse yourself in the early human periods of the Neolithic, Bronze and Iron Ages on this gentle walking tour through southwest England. From complex Iron Age hillforts, ancient stone circles and some of the area's most beautiful landscapes, discover this quaint region of south-west England. Visit several National Trust, English Heritage and UNESCO listed sites, including Stonehenge, Old Sarum, Avebury and Maiden Castle.

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NASA/RAD SINYAK

NASA/GLENN BENSON

Cosmic paint job

NASA

ART and science merge to spectacular effect in these photos, recently released by NASA. The images amp up anticipation for the upcoming Artemis II mission, which will be NASA's first crewed space flight beyond low Earth orbit since the Apollo missions of the 1960s and 1970s.

Last month, NASA workers began the hefty task of painting NASA logos on two solid rocket boosters that will provide vital thrust for the Artemis II mission. Each iconic NASA "worm" is more than 2 metres high and 7 metres from end to end. The right-hand image shows the crew working on the logo at NASA's Kennedy Space Center in Florida. The logo had been retired, but was brought back in 2020 for select merchandise.

Artemis II, scheduled for 2025, will involve a four-person crew travelling beyond low Earth orbit (2000 kilometres from the surface or above) and passing around the moon. It will test whether life-support systems are up to the job of more distant space travel.

"Under Artemis, we are going to the moon for scientific discovery and exploration and with our long-term goals in mind. We'll develop the technologies and skills we need to prepare for a future human Mars mission," says Matt Ramsey, mission manager for Artemis II.

The image on the left, also at Kennedy Space Center, shows the latest makeover of the Orion crew capsule of Artemis II – complete with newly added logos. Both Orion and the boosters are pivotal elements for deep space exploration and, crucially, for Artemis's long-term ambitions for a lunar space station.

Gege Li

Editor's pick

The one about making friends in the office

10 February, p 21

From Matthew Tucker, Sydney, Australia

In making the case for more time working face-to-face rather than from home, Robin Dunbar highlights friendship benefits of the former, adding that the ideal number of close friends for good health is five, including close family. This means most people have enough such friends without needing any at work.

In addition, the continued strong profitability of companies throughout and after the covid-19 lockdowns belies the idea that working from home somehow diminishes productivity, not to mention the impact on emissions-generating commutes. For people who love the office because of its social nature, no one is stopping you from making the journey there.

From Roger Parkinson, Wellsford, New Zealand

Dunbar suggests other people's experiences of working from home were very different from my own. Lockdowns meant no long commute each day and very few interruptions, allowing me to get more done. It is nice to work with friends, but I have friends who will remain with me beyond this job.

A good motivation to work is authorship

3 February, p 44

From Geoff Harding, Sydney, Australia

Motivation is very important in any arduous task, as David Robson highlights, but the bigger challenge is often how to maintain it. For example, much research is difficult, frustrating and prone to setbacks and possible failure. However, in supervising young, ambitious students, I found that the carrot of a probable publication with themselves as a prominent author was a strong incentive to work hard and overcome hurdles in order to bring the research to a satisfactory conclusion.

Supersonic cargo planes may appeal to military

Letters, 10 February

From Scott McNeil, Banstead, Surrey, UK

Peter Leach quite rightly derides NASA working on commercial supersonic flight. However, there is one potential important customer: the US military, which probably lacks the expertise to develop large supersonic aircraft.

I can imagine it needing these to move specialist personnel and mission-specific equipment from a central base in the US to a "hotspot" at short notice. This would seem to be more cost-effective than relying on having numerous supply depots with a broad range of equipment and personnel around the world.

Wise to widen the search for a theory of everything

10 February, p 32

From Steve Applegate, Cleves, Ohio, US

Physicists may have stalled in their search for the theory of everything because of the presumption that the universe is limited to three spatial dimensions. If they are now going to use geometry in their hunt for a final theory, they may be able to get somewhere by investigating the use of tesseracts or other higher-dimensional geometric objects.

From John Bundy, Brevard, North Carolina, US

The search for a neatly packaged theory of everything is fun and fascinating. It is often difficult for the average science buff to follow the brilliant work of geniuses. However, I believe that we wrongly expect there to be a lower "size" limit to our universe, which suggests a boundary – albeit usefully – in our search for fundamental entities.

I see no reason why the descent in size, from visible objects to hypothetical strings, shouldn't keep going, just as it probably grows ever greater in the other direction. As Werner Heisenberg famously noted: "Not only is the universe stranger than we think, it is stranger than we can think."

No bone to pick with the makers of meat loaf

13 January, p 11

From Jeffrey Clark, Portland, Oregon, US

You report the idea of grinding bones to make edible paste. In a case in point, my young son loves meat loaf. My wife and I noticed that the texture of it changed in all our usual shop-bought versions and thought there must have been some shift in ingredients that was so compelling that widespread adoption happened quickly. Our suspicion was reinforced when we noticed tiny, hard particles, which, under closer examination, looked like bone fragments. It seems like they had added bone puree.

As environmentalists, we are aware of food waste issues. Using bone paste could mean fewer animals sacrificed to satisfy the craving for meat, ideally edging us closer to not eating animals at all.

Could some have a super sense for pheromones?

27 January, p 35

From Elizabeth Carrey, Tiverton, Devon, UK

Even among humans, with our inferior olfactory senses, some of us can taste and detect scents better than others. Does the hunt for human pheromones take into account that some people may be better at emitting and/or receiving these signals? On a similar note, I have always been intrigued by the idea that menstrual cycles can be synchronised among groups, which has defied proof. Here, again, perhaps a "dominant" transmitter in the group emits a chemical signal to other members.

School students must return to pen and paper

3 February, p 19

From Sam Edge, Ringwood, Hampshire, UK

Many previous studies have found that taking notes with pencil and paper in class or when revising is more effective than doing so with a keyboard, but it was interesting to read your report on the possible neurological explanation for this effect. In light of the evidence, it would seem wrong to pursue the idea of schools issuing laptops to all students. Giving them exercise books or notepads along with pencils and pens would be cheaper and much more effective.

On the fate of record-breaking fusion reactor

17 February, p 13

From Rachael Padman, Cambridge, UK

You say that decommissioning the JET fusion reactor in the UK might take 16 years. Some people might wonder why it takes so long. The reactor has been exposed to high neutron fluxes and much of it is at least mildly radioactive, so needs to be appropriately dealt with.

You also mention the value of tritium, some of which may be embedded in the reactor and is possibly recoverable. But that may be less of a consideration in this phase. Tritium is radioactive, with a half-life of just over 12 years. By the time decommissioning is over, much of it will be gone. ▮

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New Scientist video
Watch Alice Roberts discuss how graves shed light on ancient societies **youtube.com/newscientist**

The murderous Middle Ages

Alice Roberts's latest book on what bones teach us about Britain's history not only provides the grisly facts, but helps us feel them, says **Michael Marshall**

Book
Crypt
Alice Roberts
Simon & Schuster

ANOTHER year, another really good book from archaeologist Alice Roberts. Part of me almost wants to find that the quality has slipped, just for the sheer surprise – but no, her standards are as high as ever.

Roberts may be the UK's best-known archaeologist, in part due to her many TV appearances. She has also written a string of books, including *Wolf Road*, her first children's novel. Her specialism is osteoarchaeology, the study of bones and what they can tell us about how a person lived and died.

Crypt is the final instalment in a loose trilogy about what we can learn from graves. The first book – *Ancestors,* in 2021 – was about prehistoric Britain. The following year came *Buried*, which focused on the country in the 1st millennium AD. Now, the final instalment tackles the 2nd millennium, examining Britain's Middle Ages in particular.

As before, each chapter is a self-contained look at a particular grave with a specific story to tell. You can read them in any order, although they do proceed roughly chronologically.

The first chapter is about the St Brice's Day Massacre of 13 November 1002, when England's aptly named King Æthelred the Unready (typically judged to have been a very incompetent monarch) ordered the killing of Danes living in the country.

Æthelred described the Danes as "cockle amongst the wheat", implicitly describing them as weeds – a vicious form of othering language that we have seen

MOLA/GETTY IMAGES

Above and below: London's Crossrail excavations unearthed victims of the Black Death

repeated in many subsequent genocides. Roberts explains the geopolitical situation that inspired Æthelred's vile actions, and examines whether a set of bones found in Oxford might be from some of the victims.

This illustrates a key point about *Crypt*: it gets pretty dark. It isn't so much that you'll need a strong stomach for gruesome details, though there is a bit of that, but rather that you should be prepared to read about epidemics, mass murder and suffering. The front jacket goes so far as to warn readers that the stories "are not comforting tales". But then history isn't comforting: the whole point is to learn lessons from it.

AMER GHAZZAL/ALAMY

As Roberts explores the Middle Ages, she tackles the killing of Archbishop of Canterbury Thomas Becket, the sinking of the Mary Rose and the practice of walling oneself off inside a church to become an anchorite – in one story, a woman who may well have had syphilis walls herself off in a church in York. In her retelling, Roberts draws on a host of sources: not just the bones themselves, but historical documents, ethnography and anything else that is relevant.

For me, the chapter on the Black Death was a highlight. Roberts weaves together historical accounts of the epidemic with the more recent research that uncovered the plague bacterium *Yersinia pestis*.

She also takes the time to explain why some epidemiologists argued up to the early 2000s that the Black Death wasn't really an outbreak of plague, and how more recent ancient DNA evidence has shown that *Y. pestis* was indeed involved. But the epidemic still didn't play out exactly as we thought, with transmission by humans as well as rats.

I was also fascinated by a chapter on medieval hospitals. Modern hospitals are secular and clinical institutions, but early ones were religious in nature. With few actual treatments to offer, they were more like monasteries, where people with severe illnesses could live away from the rest of society.

The hospital on which Roberts focuses, St Mary Magdalen, east of Winchester, UK, seems to have mostly housed people whose appearances were affected by leprosy, and she has a lot to say about how society understands disability and appearance.

"Medieval hospitals were like monasteries, where people with severe illnesses could live away from society"

When I reviewed *Buried* in 2022, I compared the way Roberts writes about long-dead people to Oliver Sacks's books about people with neurological and psychiatric conditions – which I meant as high praise. My point was that both writers excel at weaving together many different kinds of knowledge to create a rich tapestry. They help you understand the facts on a technical level, but they also make you feel them in your bones. ▮

Michael Marshall is a writer based in Devon, UK

The kids aren't alright

What's causing the youth mental health crisis? **Clare Wilson** discovers a bold hypothesis too disturbing to dismiss

Book

Bad Therapy
Abigail Shrier
Swift Press

MUCH has been written about rising rates of mental health problems in children and teenagers, particularly in the US, with many possible explanations proposed. In *Bad Therapy: Why the kids aren't growing up*, US journalist Abigail Shrier offers a bold hypothesis: this crisis is being perpetuated by the very measures supposed to counter it – used by families, schools and, especially, professionals.

For Shrier, the problems start with the many ways modern child-rearing differs from that of previous generations. Much of this difference is so-called helicopter parenting, when parents micromanage their children's lives to ensure they are constantly mentally and physically nurtured.

In the past, children didn't spend a large part of the day being taxied from one stimulating activity to another, but were left to get bored, make up games and rub along with the local kids, being socialised in the process. Their squabbles and scrapes helped foster resilience and turn them into functioning adults, she writes.

Another of Shrier's targets is the vogue for "gentle parenting". Previous generations "corrected and punished their way through childrearing". Today we talk to our kids in the language of therapists, which Shrier satirises as: "Sammy, I see that you're feeling frustrated. Is there a way you could express your frustration *without* biting your sister?" Small wonder if children cannot cope when they have to face the outside world's lower tolerance for their tantrums.

In fact, therapy-speak (and therapy-think) are also Shrier's targets, part of what she sees as the growing, malign influence of the mental health industry on family and school life. Children are regularly subjected to mental health screening tests, which could cause the problems they are meant to prevent, she writes.

In one example that may shock parents, Shrier recounts how, when she took her 12-year-old to the doctor with a stomach ache, he was asked questions such as whether he ever felt his family would be better off if he were dead. US schools also routinely use such surveys to ask children if they think of cutting or burning themselves. No one seems to consider the potential for putting ideas in their heads.

Shrier's case is cogent but not watertight. Her research seems to consist of interviews with families and the mental health professionals who agree with her – scientific literature, not so much.

For some, Shrier's argument will amount to "pill shaming", for instance in her description of a family who tackled their son's ADHD by giving him strict routines and chores, not drugs.

At the start of the book, Shrier says she isn't against medication for those with profound mental illness, just for a second cohort, now far larger: "the worriers, the fearful, the lonely… They go looking for diagnoses to explain the way they feel. They think they've found 'it' but the 'it' is always shifting."

The trouble is, how can parents know if their troubled child is in the first group or the second? For cynics, it may be tempting to dismiss *Bad Therapy* as another version of the claims that Gen Z are "snowflakes". However, US teens have never had so many mental health diagnoses, so much therapy and so much psychoactive medication. Whatever is causing their problems, it seems to be getting worse. If only a tenth of what Shrier writes is correct, it would be profoundly alarming.

The rising rates of mental health problems may be most pronounced in the US, but they are also worrying in other countries, such as the UK and Australia. Parents and anyone with an interest in young people's welfare should read this book – preferably with an open mind.

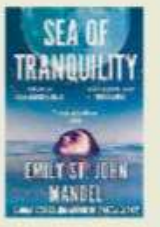
"Gentle parenting" may be creating the very problems it is aiming to prevent

THOMAS BARWICK/GETTY IMAGES

New Scientist *recommends*

Eleanor Parsons
Features editor
London

I really enjoyed **When Forms Come Alive** at the Hayward Gallery in London. Often inspired by nature, many of the sculptures felt full of life, like they could move or burst open at any time.



I was mesmerised by the tumbling forms of *Shylight* by DRIFT, a multidisciplinary team founded by Lonneke Gordijn and Ralph Nauta. It was reminiscent of opening flowers, falling blossom and frilly petticoats. Also entrancing was Tara Donovan's silver spheres in *Untitled (Mylar)*, hinting at out-of-control cell growth, while Ruth Asawa's beautiful woven sculptures made me think of the hidden complexity of seed pods.

I also savoured **Sea of Tranquility** (pictured) by Emily St John Mandel. I became a fan after I read her excellent **Station Eleven**. *Sea of Tranquility* is a thrilling mystery that flits from Canada in 1912 to 25th-century moon colonies and places in between. Think pandemic, time travel and sinister government departments. The twist made me gasp.

The film column

Archive it

Why did Ian Cheney build an ark in Maine? He wanted a visual metaphor to help his film *The Arc of Oblivion* explore which of our artefacts are worth keeping and why we even think things can last. **Simon Ings** leaps down the rabbit hole

Simon Ings is a novelist and science writer. Follow him on Instagram at @simon_ings

WICKED DELICATE FILMS

Film-maker Werner Herzog sits in the ark built for Ian Cheney's film

"HUMANS don't like forgetting," says an archivist from the Al Ahmed Mahmoud Library in Chinguetti, Mauritania. Located on an old pilgrimage route to Mecca, Chinguetti is now disappearing under the spreading Sahara desert. Not for the first time: there have been two previous cities on this site, the first built in AD 777, and both vanished under the dunes.

Ian Cheney, a documentary-maker from Maine, visits the Arab-Berber libraries of Chinguetti towards the end of *The Arc of Oblivion*, a film all about what we try to preserve and hang on to, born as we are into a universe that seems wilfully determined to forget and erase our fragile leavings.

You can understand why Cheney is anxious around issues of longevity and preservation: as a 21st-century film-maker, he is having to commit his life's work to digital media that is less durable and more prone to obsolescence than the media of yesteryear: celluloid, paper or ceramic.

Nonetheless, having opened his film with the question "What from this world is worth saving?", Cheney ends up asking a quite different one: "Are we insane to imagine anything can last?" That quote about humans not liking to forget may, in the end, be the best reason we can offer to explain why we frantically attempt to hold time and decay at bay.

This film is built on a pun. We see Cheney, various neighbours and family friends building an ark-shaped barn in his parents' woodland, made from their lumber and designed by his retired architect father. It is big enough, Cheney calculates, that if the entirety of human knowledge were reduced to test tubes of encoded DNA, he could just about close the barn doors on it all. The ability to store information as DNA is one of the wilder detours in a film that delights in leaping down intellectual and poetic rabbit holes. The friability of memory, music, ghost stories, floods and hurricanes – the list is long, but, to Cheney's credit, it never feels it.

"If human happiness is what you want, the trick may be to collect for the pure pleasure of it"

Alongside that ark in the woods, there is also an arc – the "arc of oblivion" that gives this film its title and carries the viewer from anxiety into a more contemplative and accepting relationship with time. Perhaps it is enough, in this life, to be simply passing through and taking in the scenery.

Executive producer Werner Herzog, a veteran film-maker, appears towards the end of the movie. Asked why he destroys all the preparatory materials generated by his many projects, he replies: "The carpenter doesn't sit on his shavings, either."

This is good philosophy and can be sensible practice for an artist – but it is rather cold comfort for the rest of us. At least while we are saving things we might forget, for a moment, about oblivion.

If human happiness is what you want, the trick may be to collect for the pure pleasure of it. Even as it struggles to preserve Arab-Berber texts dating back to the time of the Prophet, the Al Ahmed Mahmoud Library finds time to accept and catalogue books of all kinds, including donations from people who are simply passing by.

Cheney's cast of friends and acquaintances is long, and the film's discursive, matesy approach to their experiences – losing photographs, burying artworks, singing to remember or to forget – teeters at times towards the mawkish. But *The Arc of Oblivion* remains an enjoyable, moving meditation on the pleasures and perils of the archive. ▮

Film

The Arc of Oblivion
Ian Cheney
Sandbox Films, in some US cinemas from 23 February

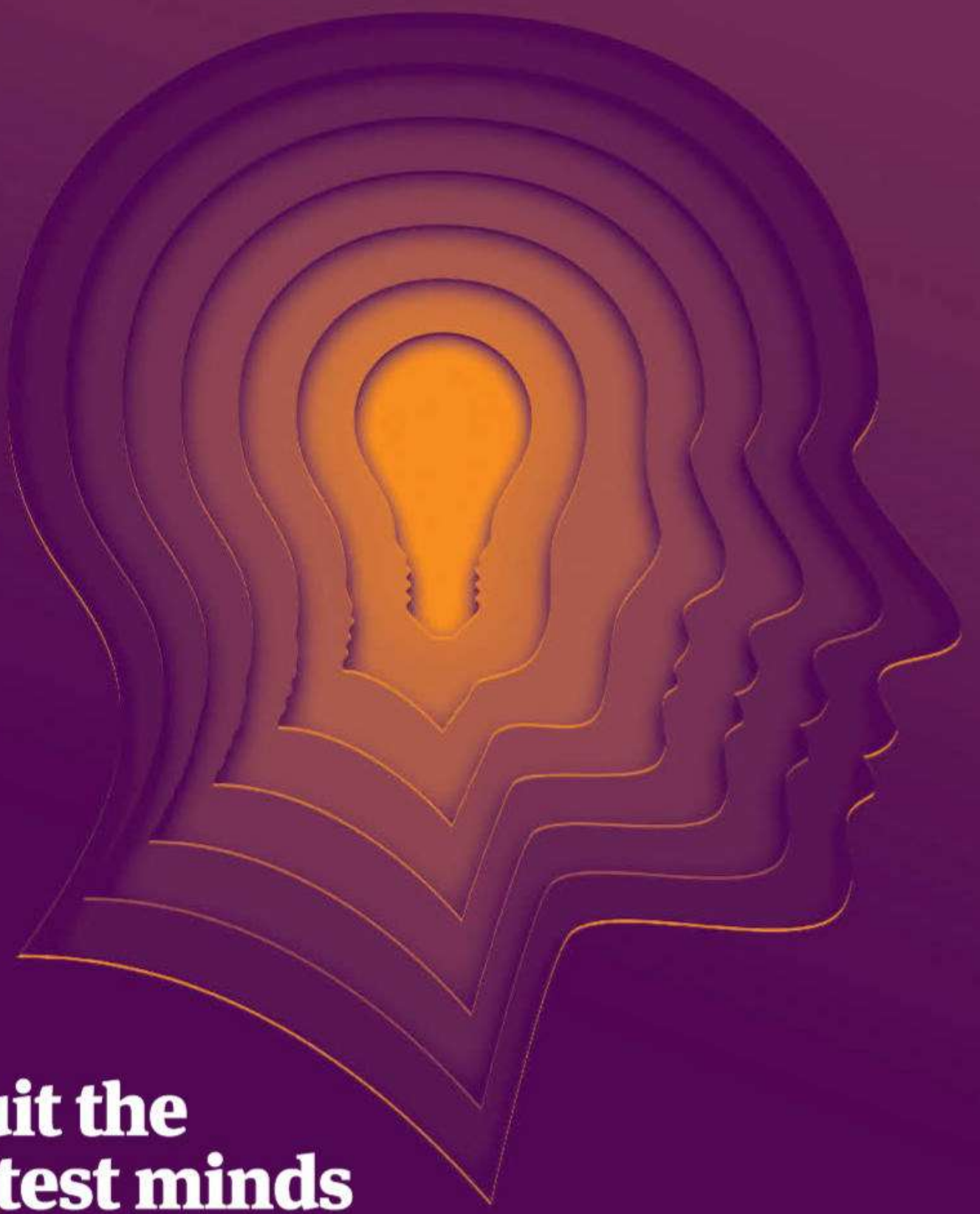
Simon also recommends...

Books

A Prehistory of the Cloud
Tung-Hui Hu
MIT Press
This short, devastating book reveals how storing data in "the cloud" makes it even more vulnerable and irretrievable than it was in the first place.

Otherlands: A world in the making
Thomas Halliday
Penguin
This epic, near-hallucinatory natural history of Earth works backwards past the Pleistocene to the first stirrings of multicellular life.

Jobs
NewScientist



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More than skin deep

It's not just a vanity project – looking after your skin could improve your health and longevity in unexpected ways, discovers **Michael Marshall**

IN WINTER, the backs of your hands may become dry, red and cracked. Maybe you find yourself slathering on moisturiser. If you don't, the itching and pain can become a major distraction.

You might think that is as far as it goes: cracked skin is annoying and uncomfortable, but not serious in the same way as, say, high blood pressure. But that assumption, like ageing skin, might not hold water.

Growing evidence suggests that damage to the skin can have knock-on effects for the rest of the body, driving inflammation, muscle and bone loss, and possibly even cognitive decline. The more your skin deteriorates, the more the rest of you ages prematurely. In this emerging view, your skin doesn't just reflect signs of ageing – it's a contributing factor. There is even tentative evidence that taking better care of our skin could slow the harmful effects of ageing and improve our overall health.

Our skin is one of the first parts of the body to show signs of ageing. It becomes wrinkly, especially in active places like the corners of our eyes, and age spots can appear. Such changes may seem – quite literally – skin-deep, but we shouldn't underestimate the skin's importance to the rest of the body. "The skin is the largest organ in the body," says Wendy Bollag at Augusta University in Georgia, US.

And it isn't just about size. The skin is crucial for survival. The outer layer, the epidermis, is impermeable to water, ensuring that we don't lose our life-giving fluids to the air. If someone damages large swathes of the top layer of their skin, or their skin otherwise stops functioning as an effective barrier, they are at severe risk of death, says Theodora Mauro at the University of California, San Francisco. This is one of the reasons why blistering diseases and severe burns are so dangerous. "People have understood that since biblical times," she says.

Nevertheless, the medical establishment has only recently realised that even less extreme skin damage can have serious effects. "People are just now coming around to the idea that inflammatory skin disease can affect your body as a whole," says Mauro.

AISTE STANCIKAITE

Beyond the barrier

Much of the evidence for this link comes from two skin conditions: psoriasis and atopic dermatitis (also known as atopic eczema). In psoriasis, the skin produces too many new cells, forming patches of flaky, scaly skin. In atopic dermatitis, some areas of the skin are dry, cracked and itchy. Both tend to be chronic conditions requiring lifelong management.

Decades of evidence indicate that these conditions are linked with a higher risk of severe harms. A 2018 meta-analysis of 19 studies concluded that atopic dermatitis was associated with a "small but significant" increase in the risk of heart attack, stroke, angina and heart failure. Similarly, several other analyses have concluded that people with psoriasis seem to be at higher risk of cardiovascular disease than those without it. Skin conditions are also linked with muscle loss, or sarcopenia. "The association is pretty strong," says Mauro.

Of course, correlation isn't causation: just because these skin conditions are associated with a range of other health outcomes doesn't necessarily mean they are causing them. However, evidence is building that there really are causal links. Both psoriasis and atopic dermatitis lead to problems with the skin's barrier function, says Peter Elias, also at the University of California, San Francisco. In response, skin cells try to repair the barrier. To do so, they release chemical signals called cytokines that trigger inflammation.

"The purpose of inflammation is to activate the immune system and to promote healing of wounds," says Bollag. An inflamed tissue is red, swollen and painful. More blood flows to it and its temperature rises. These are all signs that the body's healing systems are getting to work. "The issue is that sometimes it doesn't resolve when it should," says Bollag. Inflammation is meant to be a short-term response, but if it persists, it can become harmful. That is exactly what happens in chronic skin conditions like psoriasis.

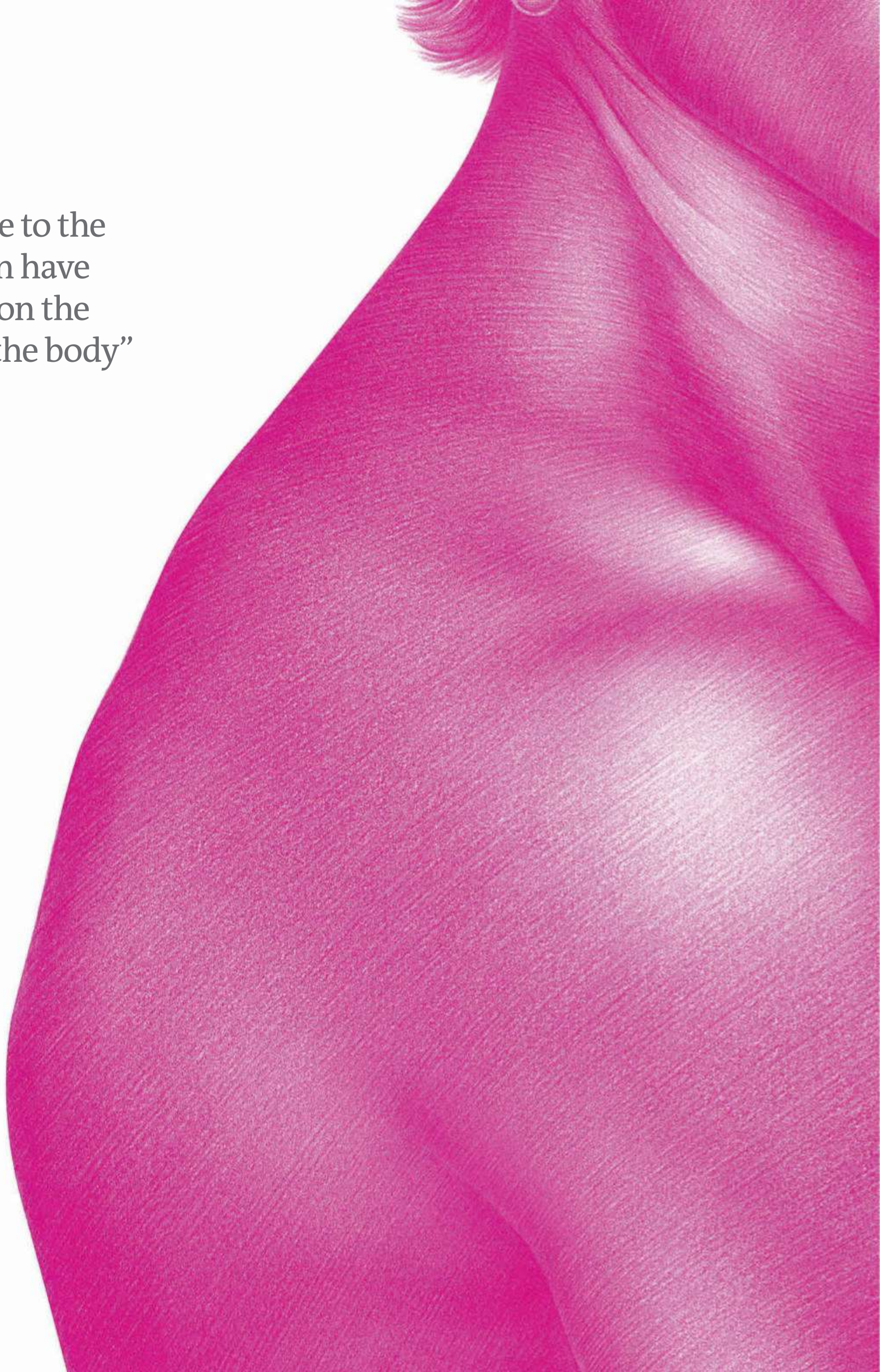
Inflammation also plays a role in ageing. For over two decades, researchers have explored a phenomenon called "inflammaging", in which older people display chronic, low-level inflammation. Their blood constantly has slightly elevated levels of cytokines compared with younger people. This continual, low-grade inflammation has been linked to a number of conditions of older age, including dementia, arthritis and type 2 diabetes. It may also play a role in age-related sarcopenia, the same sort of muscle loss that was shown to be associated with skin conditions.

"The intellectual leap that my group made was to say, well, these inflammatory cytokines you're seeing in the blood as people age are the exact same inflammatory cytokines that you see when you insult the skin," says Mauro.

To demonstrate this, she teamed up with Elias and other researchers, including Mao-Qiang Man at the Southern Medical University in Guangzhou, China. In 2017, they disrupted the skin of mice by placing cellophane tape on it and then stripping it off. Three hours later, the genes that code for cytokines were being expressed more in the mice's skin and cytokine levels in their blood rose. However, when the team restored the skin's barrier by applying glycerol or petroleum jelly, cytokine levels in the skin and blood fell again.

The key may be disruption to the very outermost layer of the epidermis, known ›

“Damage to the skin can have effects on the rest of the body”



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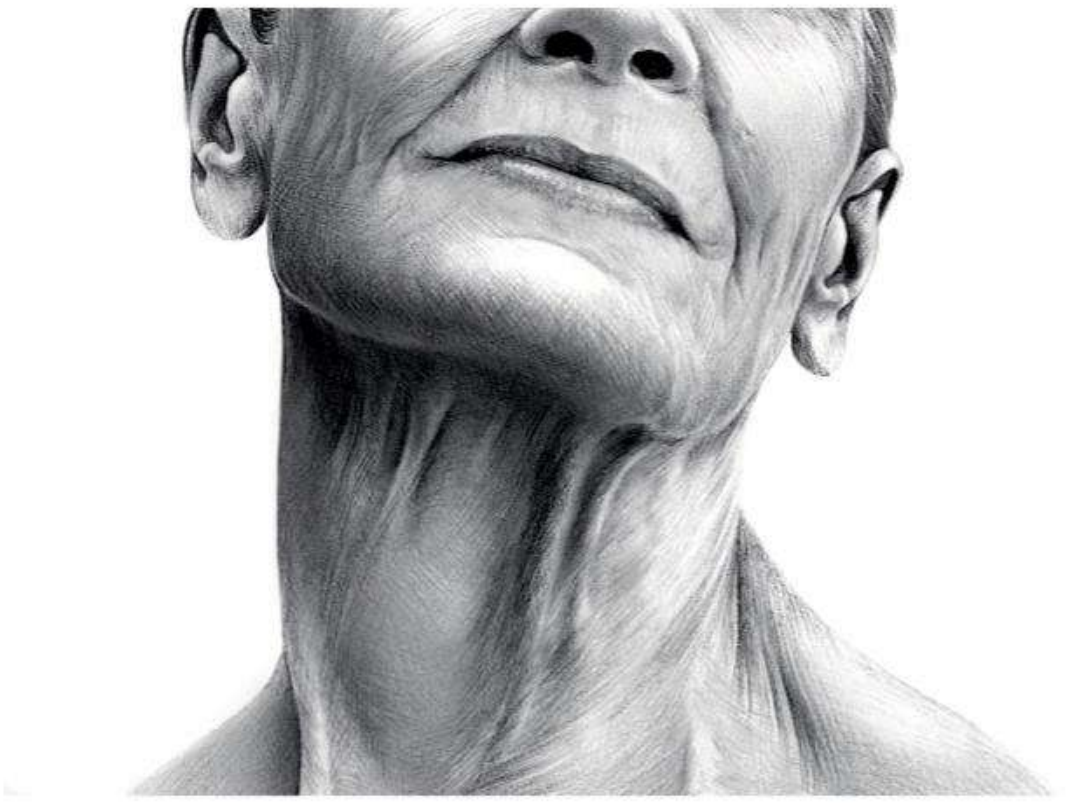


"Your skin doesnt just reflect signs of ageing – it's a contributing factor"

as the stratum corneum, or "horny layer". This is made up of dead skin cells enriched in a protein called keratin, and it is crucial to keeping water inside the body. In 2023, researchers led by Man looked at the skin and blood of 255 people aged 65 or older. The researchers found that people with less water in the stratum corneum had higher levels of cytokines in their blood.

Emerging evidence also suggests inflamed skin can contribute to inflammatory bowel disease. For example, a 2021 study led by Richard Gallo at the University of California, San Diego, investigated why skin inflammation and inflammatory bowel disease often go together. It found that when the skin of mice became inflamed due to injury or infection, a chemical called hyaluronan was released. This entered the gut and triggered an immune response.

Skin damage may also contribute to bone loss, according to a 2022 study by Wenquan Liang, also at Southern Medical University, and his colleagues. Mice whose skin had been damaged in a way that mimicked ageing lost bone mass. The team linked this to skin cells releasing less of a protein called cystatin-A, which normally regulates the behaviour of bone cells. When the damaged skin produced less of it, the bone cells behaved abnormally and the bones became weaker. Smearing a chemical called calcipotriol on the mice's skin triggered the production of cystatin-A and reduced the bone loss.

The effects of skin damage may even reach into the brain, says Elias. "There's an association now that we have shown, convincingly, for Alzheimer's and dementia," he says. A number of studies have found that people with inflammatory skin diseases are more likely to display cognitive impairment or dementia. Indeed, other research has also suggested that inflammaging plays a role in the development of these conditions.

Another important factor in the skin's impact on our well-being is via touch (see "The importance of touch", page 35), but perhaps the most obvious – albeit overlooked – way this organ shapes our health is that a weaker skin barrier, caused either by disease or by ageing, could allow harmful chemicals and particles to sneak into the body and cause more widespread damage. "What my lab has been working on, and what we're getting close to showing, is that there is an additional barrier defect in ageing, which is that things get in there," says Mauro. She points to a 2021 study that tracked appointments at dermatology clinics following the 2018 California wildfires. People who had been exposed to the air pollution from the fires were more likely to report that their atopic dermatitis had got worse.

Despite the growing evidence for the impact of our skin on our overall health, plenty of uncertainty remains. For one thing, it isn't clear to what extent these changes are being driven by the skin – as opposed to the skin being caught up in something that is being driven by another organ.

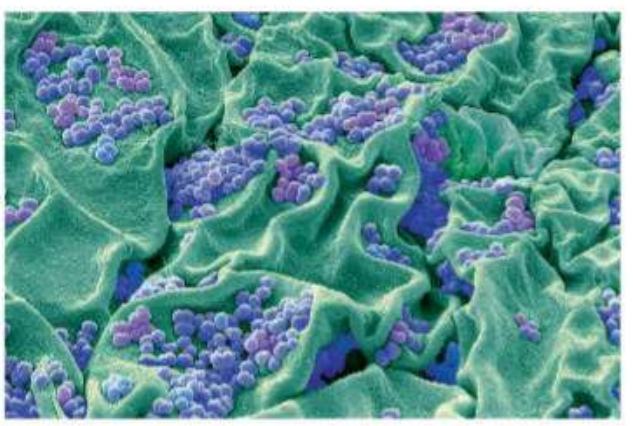
"We don't really know yet whether the things we measure in skin are a reflection of systemic health influencing the skin or whether, because of the size of the organ, changes in, for example, immune cells that are resident in skin are influencing systemic health," says Rachel Watson, executive director of A*STAR Skin Research Labs in Singapore. "There's still some debate as to what's driving the process."

Mauro says that there is a lot of cross-talk between different bodily systems, so it probably isn't an either-or situation. And even within the skin, multiple mechanisms seem to be at work. One factor is zombie-like senescent cells, which build up as we age, not just in the skin but throughout the body. "They don't die, but they're not normal, and it turns out they're pretty inflammatory," says Mauro.

Support is also mounting for the importance of the skin microbiome in all this. Like other parts of our body, the skin is home to a huge variety of microorganisms, including bacteria, fungi , including bacteria, fungi and viruses. "Until recently, it was not. "Until recently, it was not appreciated how much the microbiome affects the skin and then how much the skin affects systemic health," says Gallo. We now know that a healthy skin microbiome helps build our immune system in early life, as well as enhancing the barrier function of skin and regulating the activity of skin cells.

For instance, Gallo's team has spent years investigating a species of bacterium called *Staphylococcus aureus*, which lives on our skin and can become infectious. Healthy skin is

Our skin is home to around a thousand species of bacteria



STEVE GSCHMEISSNER/SCIENCE PHOTO LIBRARY

good at fighting this microbe off, but people with atopic dermatitis often have greater numbers of *S. aureus* on their skin than those without. "Part of it is the body's immune problems leading to increased susceptibility to [bacterial] growth," says Gallo. His team has found that *S. aureus* infection increases inflammation in the skin, which could then have for the rest of the body.

Other bacteria on the skin matter too. Some other *Staphylococcus* species, such as *Staphylococcus hominis*, compete with *S. aureus* – protecting our bodies in the process. But people with atopic dermatitis have fewer of these helpful bacteria. "People with that disease have parts of their healthy microbiome that are missing," says Gallo. This means *S. aureus* can run wild, making the atopic dermatitis worse and driving up inflammation.

Skin boost

The obvious implication of all this is that treatments that improve our skin could also improve our overall health, reducing our risk of a range of conditions, not least cardiovascular disease or dementia. There is already evidence of this for people with skin conditions. "If you treat psoriasis, there are less heart attacks," says Gallo.

In theory, this could apply to everyone: as our skin ages and starts driving inflammaging, skin treatments could reduce the effect. However, few supposedly anti-ageing skin treatments have been rigorously tested in high-quality randomised controlled trials. A rare exception is research conducted by Watson in 2009 and her colleagues, which showed that one over-the-counter skincare product (the manufacturer of which funded the study) could improve signs of skin ageing, reducing wrinkles and restoring levels of a crucial protein called fibrillin-1. "That was a great big surprise," she says. "We went into the research with healthy scepticism."

But could the effects of skin creams go beyond the skin? In 2019, Man, Mauro, Elias and their colleagues tried to find out. In a pilot study, they gave 33 older people a skin cream containing three types of skin lipids – cholesterol, free fatty acids and ceramides – twice a day for 30 days. (Man and Elias were consultants to the product's manufacturer at the time of the research.) Compared with controls, those who used the cream had skin that became better at retaining water, and levels of cytokines in their blood fell.

Building on this, in 2022, Elias, Man and their colleagues went back to the purported link between damaged skin, inflammation and brain function, and decided to see if repairing older people's skin could alleviate cognitive deterioration. They recruited 200 people aged over 65 from two Chinese cities. Half were given the skin cream to be applied twice a day between the colder months of November and May each year for three years. The other half got nothing. Over the three years, the control group showed increasing water loss through the skin and steady cognitive decline. The people given the cream had a more hydrated stratum corneum, and their cognitive scores stabilised relative to the controls.

Mauro emphasises that these studies are only pilots. So while the results are "promising", she says, "I don't think the evidence is strong enough yet that we can say there's an absolute benefit." Watson points out a further uncertainty: ethnicity. We know that people with different skin colours have subtly different skin structures and that their skin ages differently, so the most effective treatments may vary between people.

There is also the issue of which serums and creams to use, out of the vast range available. Traditionally, skin moisturising lotions have been based on petroleum products, which coat the skin in a water-repellent lipid layer. More recently, however, "barrier repair" formulations, containing specific lipids that become depleted in the outer layer of our skin when it dries out, have been developed, and there is some evidence to show that these provide superior benefits compared with traditional moisturisers.

Some skin experts recommend products containing glycerine, which acts as a humectant, drawing water into the skin. "If you're going to put on lotion, make sure it's got lots of glycerine," says Bollag. There is decades of evidence that it improves barrier function, she says. Beyond this, lifestyle choices can help. "Much of this is kind of common sense," says Watson. You need some sunlight because it drives the production of vitamin D in your skin, but don't get too much and avoid sunburn.

Looking far into the future, we may one day be able to completely rejuvenate our skin: in 2022, researchers created a method that can turn back the biological clock on skin cells by 30 years, by exposing them to molecules that reverse development. But until then, it may be worth paying more attention to soothing that irritated skin. ▮

Michael Marshall is a science writer based in Devon, UK, and author of *The Genesis Quest*

The importance of touch

Our skin is a major sensory organ, detecting pain, itching and temperature – as well as the often-overlooked sensation of touch.

Anyone who lived alone through the covid-19 lockdowns will know the importance of touch. Hugs are good for us, and if you go too long without being touched, it can take a toll on your mental health. In a 2023 paper, Julian Packheiser at the Netherlands Institute for Neuroscience in Amsterdam and his colleagues conducted a review of touch interventions. Drawing on 212 studies, they found that touch could reduce feelings of depression and anxiety in children and adults.

Mounting evidence shows that touch can benefit our physical health too. For instance, being touched can lower our heart rate and decrease levels of cortisol, a stress hormone. Massage therapy has been shown to help alleviate pain. Likewise, being deprived of touch is bad for you: babies and children who aren't touched often experience developmental delay.

Packheiser and his team's study found that for most people, it didn't matter whether they were being touched by someone familiar or a healthcare professional. However, newborn babies got the most benefit from being touched by their parents: this even helped them to gain weight faster.

ELOISA RAMOS/WESTEND61 GMBH/ALAMY

The hunt for alien moons

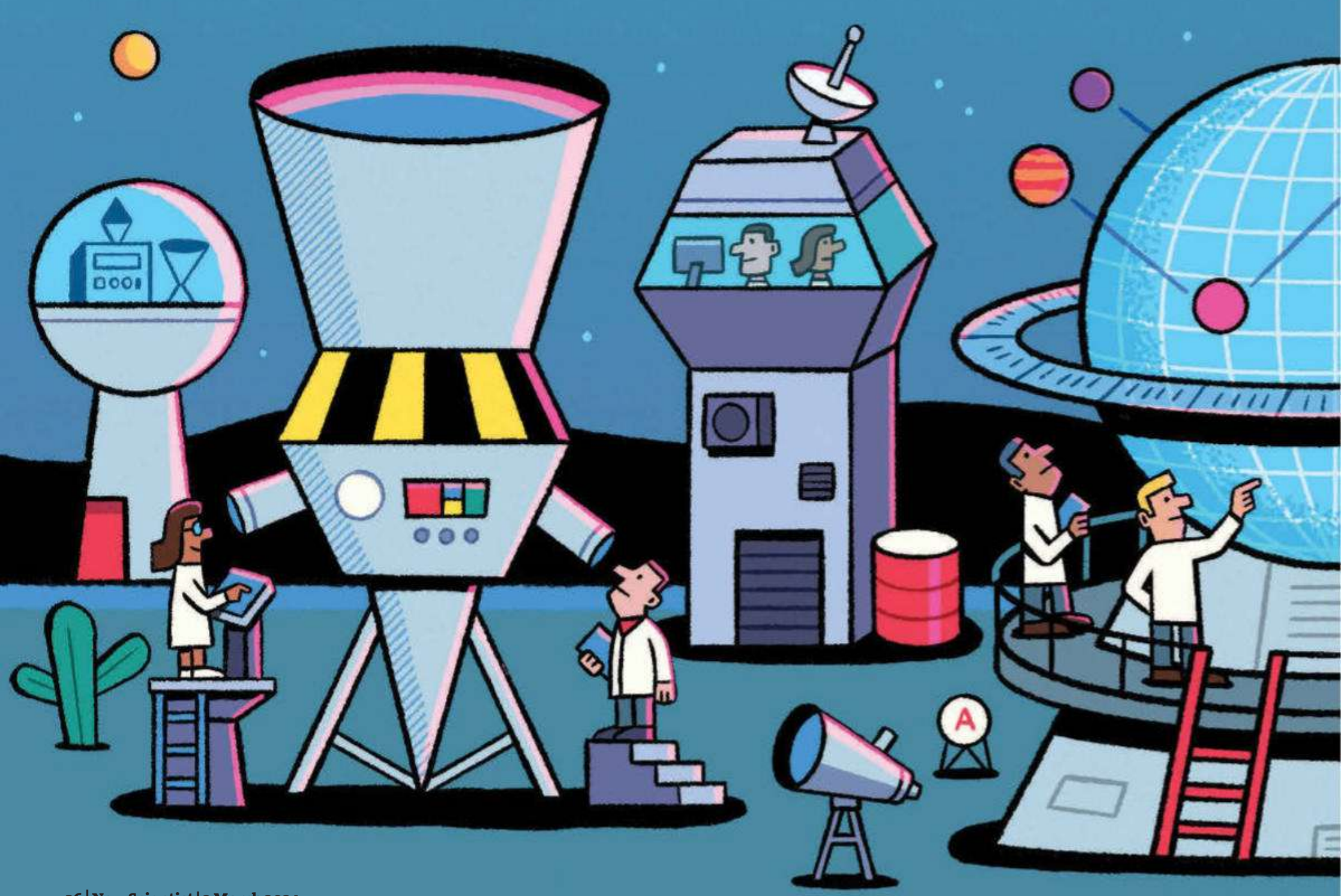
Planets orbiting other stars could host all manner of exotic moons, some of which may be habitable – and we are finally on the cusp of finding them, says **Jonathan O'Callaghan**

YEARS ago, when David Kipping lived in London, he would walk home through the city and look up at the moon. As an astronomer, its faintly glowing presence served as a nightly source of inspiration. "It was a reminder that moons were waiting for us around exoplanets," he says. "It just made sense that we should look for them."

Finding exomoons – natural satellites of worlds beyond our solar system – would be thrilling. For a start, they may play a key role in determining the habitability of host planets by damping their wobbles, fostering a stable climate in the same way that our moon has done for Earth. They might also come in weird and wonderful configurations, such as rings of moons and moons with their own moons. But most excitingly, it is possible that some of them are more hospitable to life than exoplanets.

Kipping, now at Cornell University in New York, is part of a small community of astronomers who search for exomoons.

ALLAN SANDERS



The statistics, at least, are on their side: we have found some 5500 exoplanets so far, and some of these could have dozens of moons. The trouble is, proving their existence isn't straightforward. The two sightings Kipping has made so far are hotly disputed.

But now, hope is on the horizon, with a host of new ways to search for these objects – from watching rogue planets that have abandoned their stars to monitoring the gravitational wobbles of exoplanets. Armed with these new techniques, and with new telescopes on the way, the moon hunters are on the cusp of discovering a whole new class of alien worlds.

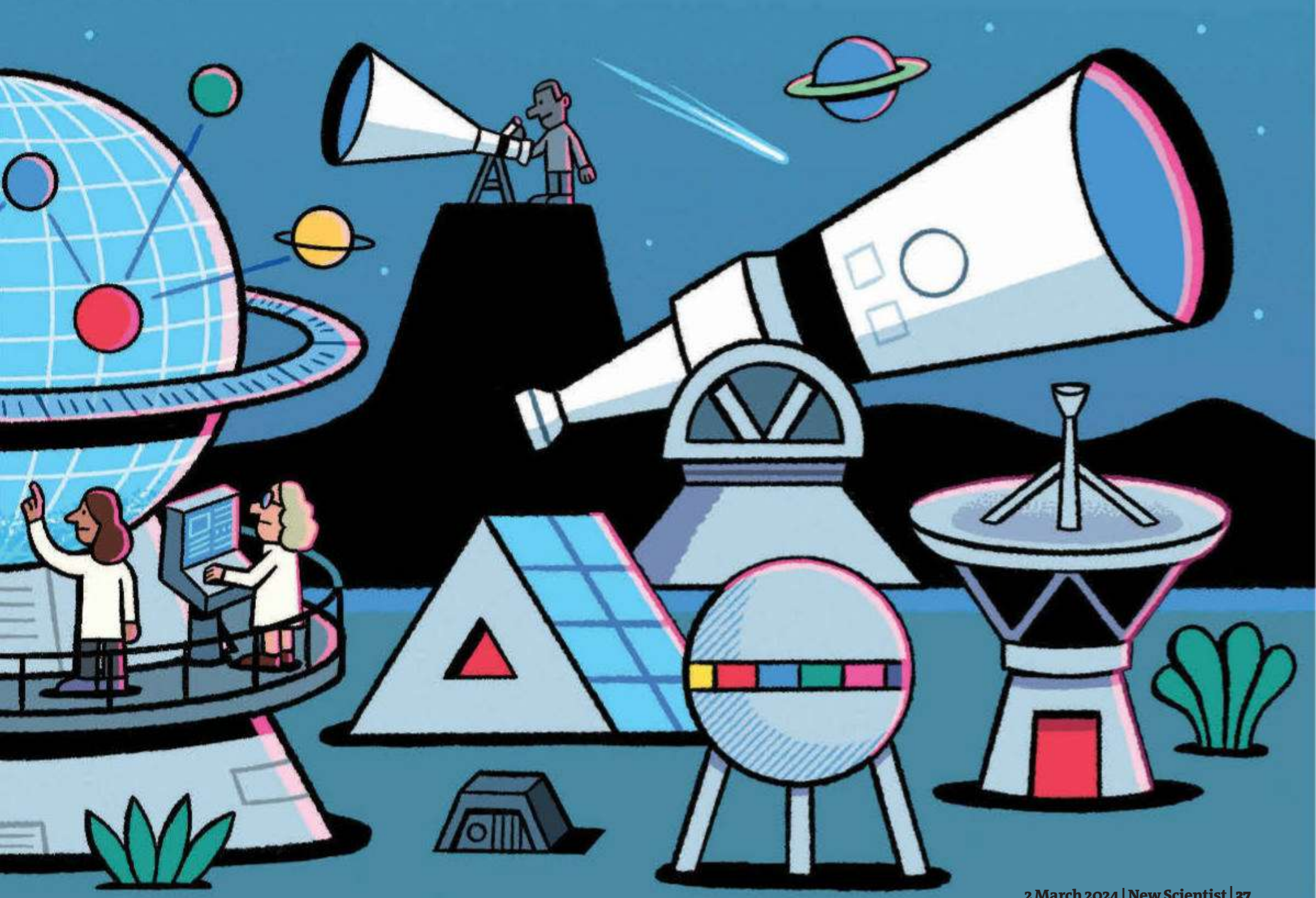
If our solar system is anything to go by, moons are everywhere – six of our eight planets have them. Earth has a solitary and sizeable one, while Mars has two small asteroid-like companions. The four giant planets host the most extensive satellite systems, with Saturn currently holding the record at around 150 known moons.

There isn't just one way to make a moon, either. Our own appears to be the result of a chance event that saw a Mars-sized object slam into us 4.5 billion years ago, its tidal effects playing a key role in the evolution of life on Earth since. The moons of Mars, on the other hand, are probably captured asteroids, while Jupiter and Saturn's may have formed in discs of debris around the planets.

Moons can come in all manner of configurations, too. Two of Saturn's – Janus and Epimetheus – almost share an orbit. But it could get weirder than that. "In principle, you could have crazy things like rings of moons around planets, like Saturn's rings but moons instead of tiny little particles," says Sean Raymond at the University of Bordeaux in France. Along with Juna Kollmeier at Carnegie Observatories in California, Raymond has even postulated that, under the right conditions, moons could have their own moons. These are called moonmoons.

Astronomers started thinking about exomoons in earnest when the first exoplanets were discovered in the 1990s. Darren Williams, now at Pennsylvania State University, was a graduate student around this time. "Very quickly, the number ballooned from zero to 10," he says. "All of these planets were giant Jupiters. I said they're going to have moons, and some of the moons are going to be big enough to support life."

Moons could be intriguing locations to look for life if they are large enough to hold onto sizeable atmospheres. The cut-off for this is surprisingly small, barely one-tenth the mass of Earth, says Lisa Kaltenegger at Cornell University. "There is no reason why an exomoon couldn't be inhabited," she says. And while planets are likely to need to orbit in a star's habitable zone to host liquid water and life, a moon could be heated by a planet in a much wider orbit around a star. "These moons could be much further out to be warm enough for life," says Kaltenegger. "It's much easier to keep them from freezing in the interior ›



“In the exoplanet game, people are really used to slam dunk discoveries”

because of the tidal heating from the planet.”

Take our solar system as an example. We know that Jupiter’s tidal forces keep its four largest moons warmer than they would otherwise be, by squeezing them, which generates heat through friction. Saturn’s atmosphere-laden moon Titan, meanwhile, is the only known place besides Earth with lakes and seas on its surface, albeit ones filled with liquid hydrocarbons instead of water.

A habitable moon orbiting a gas giant might have an amazing sky, especially if the moon were tidally locked – with one face always pointing towards the planet – like our moon is to Earth. One side of such a satellite would live under permanent planet-shine and never experience full night. “You could walk on that moon [from the far side to the planet side] and the planet would start to come into view,” says Kaltenegger.

All of which is to say that exomoons are wondrous places. So how do we find them? And why are we yet to confirm a sighting?

Jean Schneider at the Paris Observatory was the first to tackle one of those questions. In 1999, astronomers had broken fresh ground by spotting an exoplanet using a new technique called the transit method – noticing the dip in a star’s light as a planet passes in front of it – which has since become our predominant way of finding these worlds. In theory, thought Schneider, the same technique could reveal exomoons. He worked out that an exomoon should cause a slight shift in a planet’s transit depending on whether it is in front of or behind the planet as it crosses the star’s face. These are now called transit timing variations. “It gives you the revolution period of the moon around the planet, and the amplitude of the variation gives you the mass of the moon,” he says.

The first real attempt to search for a moon around a transiting exoplanet was made with the Hubble Space Telescope in 2001, with no luck. But the field of transiting exoplanets was revolutionised in 2009 with the launch of NASA’s Kepler telescope, a wildly successful mission that found more than 2700 transiting worlds in its nine years of observation. It was as a result of these sightings that Kipping began to think seriously about the possibility of finding exomoons.

As the Kepler discoveries poured in, he and his colleague Alex Teachey at the Academia Sinica Institute of Astronomy and Astrophysics in Taiwan went through the data with a fine-tooth comb to look for exomoons. The problem was that many of Kepler’s discoveries were hot Jupiters, gas giants on tight orbits around their stars. This appeared to rule out exomoons because the gravitational pull of the stars in such locations would be likely to rip away any moons.

As such, from an initial look at 300 Kepler planets in 2016, Kipping and Teachey came up almost empty-handed. “I remember being very depressed,” says Kipping. “I went to Alex’s office and I said, ‘Is there anything in here at all?’” There were no clear exomoon signals.

The only potential hit the pair found was around a gas giant called Kepler-1625 b, which is 8200 light years from Earth and about the same size as Jupiter, but with a much greater mass. The pair were given time on Hubble in 2017 to observe the planet in more detail and they found a transit timing variation suggesting the presence of an exomoon, which they dubbed Kepler-1625 b I. To cause the signal, the moon would have to be huge, with a radius on a par with that of Neptune.

Unfortunately, upon further inspection, the data turned out to be inconclusive. No amount of analysis could unequivocally confirm the signal the pair had seen. “There’s been some controversy,” says Kipping. “I remain very sceptical myself.”

Super-moons

Then, in 2022, Kipping and Teachey revealed a second exomoon candidate around a Jupiter-sized planet about 5600 light years away called Kepler-1708 b. This moon would be much smaller than the first candidate, but still huge compared with any in our solar system: a mini-Neptune or super-Earth-sized object more than twice the size of our planet. Kipping describes the candidate as “basically something we just couldn’t kill… a persistent signal of an exomoon that we can’t get rid of”.

Not everyone agrees, however. In December 2023, René Heller at the Max Planck Institute for Solar System Research and Michael Hippke at the Sonneberg Observatory, both in Germany, published a paper refuting the existence of the two exomoons. Reanalysing the original data, Heller and Hippke said they couldn’t find the same evidence as Kipping and Teachey. “We conclude that neither Kepler-1625 b nor Kepler-1708 b are likely to be orbited by a large exomoon,” they wrote.

But Kipping says there were flaws in Heller and Hippke’s analysis. “We’ve used their exact dataset they published and we can still recover the signal,” he says, having penned a rebuttal to the pair’s work in January. “To me, there’s no doubt their algorithm has missed this solution somehow.”

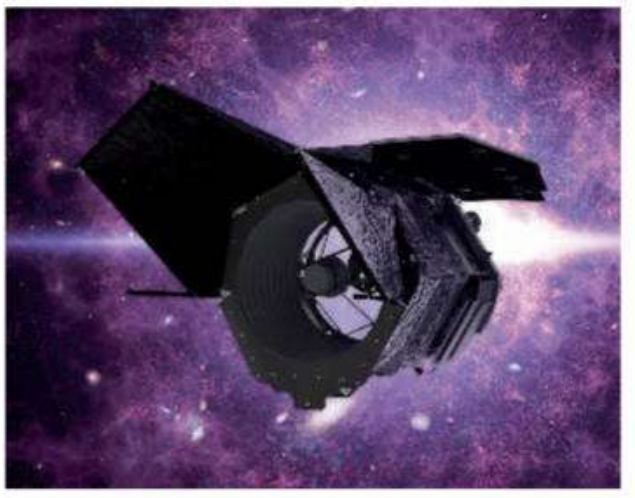
This back and forth shows how difficult it is to confirm an exomoon detection using Kepler and Hubble data, and Kipping’s detections remain tentative at best. “They’re not slam dunks, and in the exoplanet game, people are really used to slam dunks,” says Teachey.

Finding out if the moons exist for certain would require further observations over many hours. Instead, a better bet may be to look elsewhere – around free-floating planets, for instance. Also known as rogue planets, these worlds have been spotted drifting through our galaxy by the likes of the James Webb Space Telescope (JWST), glowing from their residual heat – which could also provide

energy for potential life. These wandering objects, likely to have been ejected from orbits around young stars, could perhaps be acting as roaming oases of habitability.

If these rogues have any large moons in orbit, spotting their transits should be possible. "You can monitor them in much the same way you would monitor a star for a transiting exoplanet, but instead of an exoplanet, you are seeing moons," says Melinda Soares-Furtado at the University of Wisconsin-Madison.

A NASA observatory set to launch in 2027 aims to do just that. The Nancy Grace Roman Space Telescope, known simply as Roman, will stare at portions of the sky for long periods. Its primary goal is to seek transiting planets, and it is expected to find as many as 100,000 of these. But Soares-Furtado and Mary Anne Limbach at the University of Michigan and their colleagues calculated in 2022 that the telescope will also be particularly sensitive to exomoons orbiting free-floating worlds in the Orion nebula. This is the closest region of intense star formation to Earth, where there are thought to be rogue planets. More than a dozen transiting exomoons are likely to be detectable there if they exist, the researchers found, right down to the size



GSFC/SVS

Artist's impression of NASA's Nancy Grace Roman Space Telescope

of Jupiter's moon Callisto or Saturn's Titan.

Such discoveries would also give us a good handle on how prevalent exomoons are likely to be. "You can do large-scale statistics," says Soares-Furtado. If these moons turn out to be as numerous as we think, it could dramatically increase the number of locations where we might one day look for life. "It increases the number of places to look by around a factor of 100 if our solar system is not unique in the number of moons that we find here," says Soares-Furtado. This estimate is based on the fact that, in our solar system, there is around a factor of 100 more moons than planets.

The majority of exoplanets Roman is hoping to discover will be in orbit around stars. It will find them using yet another technique, one called microlensing, which looks for the bend in light from a distant star when a closer star and any accompanying planets pass between it and our line of sight. That method should be able to detect exomoons, too, "all the way down to about twice the mass of the moon, or the mass of Jupiter's moon Ganymede", says Scott Gaudi at the Ohio State University, who leads Roman's exoplanet team. It could even spot some moons comparable to our own around Earth-mass planets. "We're not going to get thousands of exomoons with Roman," he says. "But we're going to start to detect how common these things are."

The cadre of scientists looking for exomoons is small, probably because of how hard it is. But they are determined and innovative. Andrew Vanderburg at the Massachusetts Institute of Technology, for example, wants to detect exomoons in a totally different way, by noting the slight gravitational wobble in a planet caused by the presence of a moon. Upcoming big, ground-based telescopes, like the Extremely Large Telescope – expected to finish construction in Chile around 2028 – would be particularly suited to this technique. "If you can take observations of the planets themselves, getting light using direct imaging, you can look for moons," he says.

There are also grounds for optimism in new telescopes designed to look for exoplanet transits, only this time with enough accuracy to make an exomoon detection in a star system. An upcoming European Space Agency (ESA) instrument called Plato, set to launch in 2026, might be sensitive to moons down to the size of Earth, says Ana Heras at ESA in the Netherlands, who is the project scientist for the mission. NASA's Habitable Worlds Observatory, a proposed successor to JWST intending to launch in the 2040s to image Earth-like planets and hunt for life, might go even further – picking out the reflected light of exomoons as small as our moon in the light of those planets. "Habitable Worlds is absolutely incredible for exomoons," says Limbach.

All those plans are exciting, but they mean waiting years, if not decades, for any sightings. Luckily, there is a telescope already in use that could find moons as small as Europa, which is about 90 per cent of the size of Earth's moon. "JWST is the first telescope humanity has ever built that can find those moons," says Kipping.

To their frustration, he and others have submitted multiple proposals to the Space Telescope Science Institute (STScI) in the US, which runs JWST, to use the instrument to hunt for exomoons, but they have had no luck so far. Scientists peer-review proposals to use JWST and advise STScI on what programmes to approve, but Vanderburg says that the exomoon ones are "consistently getting trashed in the reviews because they're unproven science. Until we have that first detection, that's how it's going to be."

But the moon hunters won't give up. Kipping and his colleagues will find out in March if their latest STSci proposal to hunt for exomoons has been successful. His team has identified three planets that could be prime locations for this: two gas giants and one super-Earth. "Those moons really, really should be there," says Kipping. But only one existing telescope can find them. If one of their JWST proposals is finally selected, they will be able to do one of the most advanced searches for exomoons yet. We are almost certain they exist. But it is "not good enough to say they're out there," says Teachey. "Somebody's got to go find them." ▮

Jonathan O'Callaghan is a freelance writer based in London

How to see things in a new light

Our brains stop noticing things – good and bad – that are familiar. Learning how to overcome this tendency can boost your happiness, make you more creative and even help to instigate social change, **Tali Sharot** tells Alison Flood

IMAGINE jumping into a swimming pool. It's cold, right? But then, a few minutes later, you are used to the temperature. Or how about walking into a room filled with cigarette smoke. It stinks, but give it a while and you don't notice it any more.

This is habituation – the brain's ability to stop paying attention to certain things. It doesn't only apply to sensory perceptions. It is also why new clothes or a new home lose their shine over time. And it doesn't only apply to good things: it can explain why people stay in bad relationships, why we don't raise an eyebrow at the fact that most CEOs are male and why we stop noticing the smog engulfing our cities.

Habituation is a fundamental neurological process vital to our evolution, helping us to quickly adapt to our environments so we are ready for the stuff that is new and potentially beneficial or the hazards that may be threatening. But there are benefits to seeing the things we are used to in a fresh light or – as Tali Sharot and Cass R. Sunstein put it in their book *Look Again: The power of noticing what was always there* – "dishabituating".

Sharot, a professor of cognitive neuroscience at University College London, tells *New Scientist* why learning how to dishabituate can improve our happiness, increase our awareness of misinformation and even help us fight climate change.

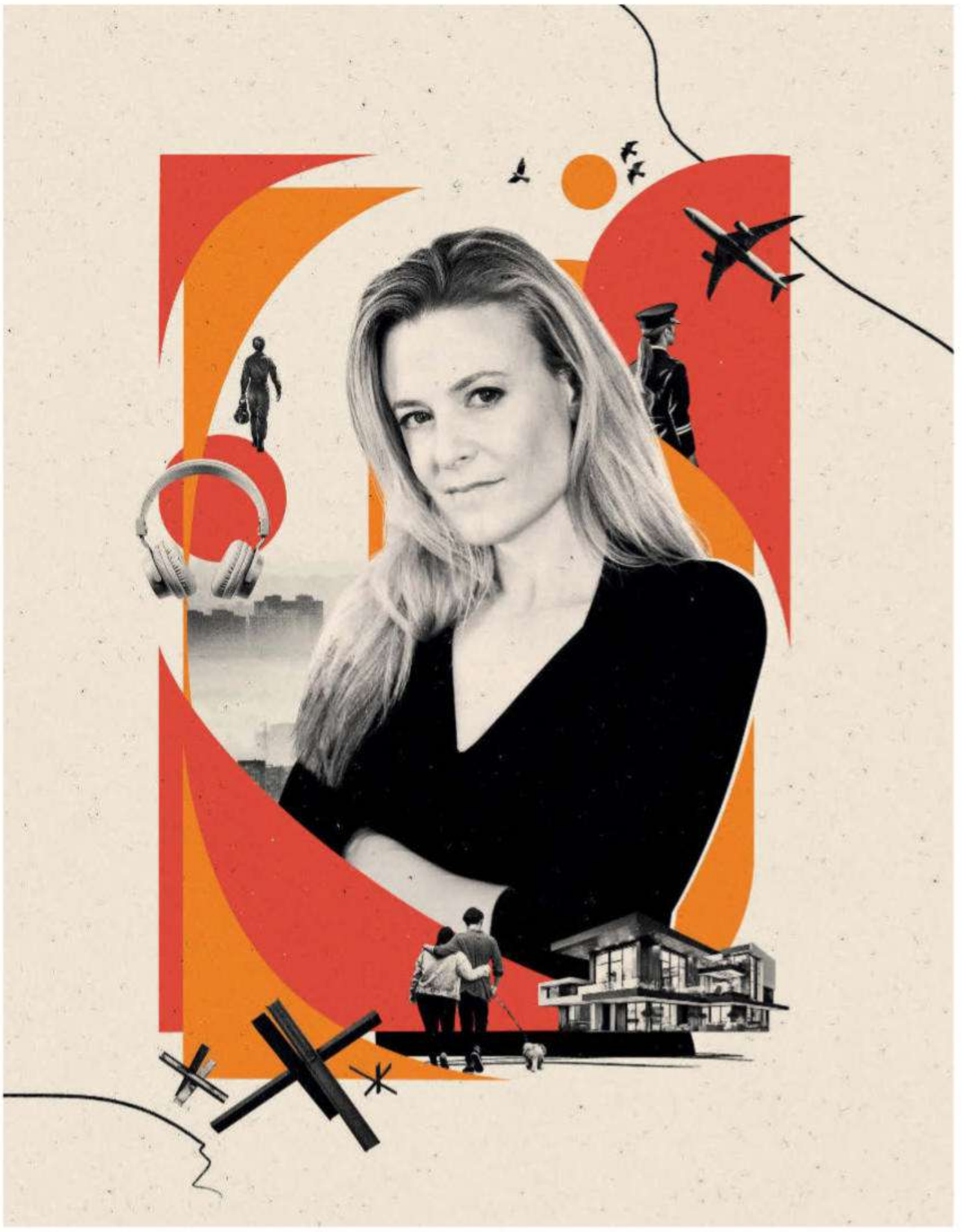
Alison Flood: Why have we evolved a brain that habituates?

Tali Sharot: The brain cares about what is new, rather than what has always been there. It makes evolutionary sense to stop responding to things that have always been there or that are changing very gradually, so you can be ready for the next thing that is coming. But like anything in evolution, those things that may be good for us on average can also have a negative effect.

In the book, you talk about how we can become habituated to being lied to – and to misinformation. Tell me more about that.

There's a well-known effect in psychology called the illusory truth effect, which is basically that when you hear something more than once, you're more likely to believe it. One of the reasons for this is that when the brain encounters anything again, it responds to it less. The first time you hear a piece of information, you're really processing it – say, "a shrimp's heart is in its head". When you hear it for the first time, you're really thinking about the sentence, you're imagining the heart in the head. But the second time I say it, your brain doesn't have to process it any more and so it's not responding to it. It is familiar, and we are accustomed to the idea that if something is familiar, it is probably true.

We usually have a surprise signal in our brain that indicates something is not true. ›



KLAWE RZECZY

P. KIJSANAYOTHIN/GETTY IMAGES

Habituating to what we see on social media can be problematic

But if that surprise signal is reduced or eliminated, and it could be only because we've heard something more than once, then we are not attuned to look at things carefully and be suspicious of their validity.

Can you become habituated to your own lying, if you do it a lot?

I was part of a team that published a study in 2016, where we showed that when people get the opportunity to lie at the expense of another person for their own gain, they start with really little lies. But over time, they get used to this, and then they lie more and more. While they were doing this, we recorded their brain activity. At the beginning, when they lied, there was a strong response in the amygdala, the part of the brain that is important for emotional reactions. We know that people think lying is bad, so it makes sense that people feel bad when they lie. They have this strong emotional negative reaction.

But the amygdala habituates over time in response to the same stimuli. It's emotional habituation. So the next time people lied, there was less of a response, and so on. Usually one of the reasons we don't lie is we feel bad about it, but the more you do it, the less bad you feel.

Is social media habituating us to images of terrible things, like war?

I believe it is, which is concerning. Social media has also completely changed what we perceive as acceptable discourse. This is a problem that needs to be solved at a higher level, involving regulations and changes to the structure of the platforms, not at an individual level.

Do we also get used to pollution because of habituation?

The most fundamental examples of habituation are to perceptual things, like what we see, what we hear, what we feel. There's a great study in which people were shown photos with different levels of smog and they were asked to say whether the photos were smoggy or not. What they found is that people who lived in Los Angeles, one of the most polluted areas in the US, were much less likely to be able to detect the smog, versus people who lived in places with fresh air, like Wyoming. This is also a problem in detecting the consequences of climate change, because climate change is so slow that people get used to it.

Is it possible to overcome habituation?

You can dishabituate yourself by taking yourself out of an environment, because when you come back you're going to see it with fresh eyes, whether it's a few days away from home, making changes to your routine, trying a new skill. I have begun taking courses in a field different from my own. I work on different projects in different industries and on different topics. By diversifying your life, you are more likely to dishabituate, which means learning new things, but also seeing the things that are already there in a new way. Basically, any breaks that we have from people, from environments, will cause us to dishabituate.

So even small breaks can help?

It's very counterintuitive in some ways, because when you're having fun, you don't want to have breaks. But in one experiment, researchers asked people if they wanted to listen to a whole song from start to finish with no interruptions, or with interruptions. Almost everyone said: "I don't want interruptions." But then the people with the breaks ended up enjoying the song more. That's not something we would intuitively predict. But with anything that's good, it's really good in the beginning and then the joy dwindles because we habituate. But if you take a break and then you go back, now the joy is high again.

On a similar note, having shorter vacations may be better than having one long vacation. We found that 43 hours in is the happiest point. From then on, it just starts going down.

How can we stop ourselves from being habituated to something huge like air pollution or climate change?

This is a difficult one because there are things that you could do in the short term, like it might be interesting to put some clean air chambers around town, where you go into the chamber and then when you come out, you're dishabituated to the air quality and you're able to perceive the smog. However, I think that by realising we cannot perceive climate change, it should really make us rely on the data, right? Our feelings can deceive us. And so we need to go with the measurements and what they're telling us.

Talking of measurements, you write that women's self-reported happiness has actually gone down as gains have been made in terms of equal rights. How does habituation come into this?

In the 50s and 60s, before the women's rights movement really accomplished many gains, women in the US reported higher levels of happiness and self-confidence than women there do now. That's surprising because it seems that as we gain equality, we are actually becoming less happy. This is partly a matter of habituation and how it affects our expectations. Back then, women had become habituated to the status quo: they would not expect to get high-level jobs, they didn't expect to have their own wealth. Nowadays, we do expect that, and we're told that we can do it. But, of course, that's not

quite true because there's a lot of hurdles.

So we think we should get as good a job as our male colleague, but we don't actually achieve that. And that then creates what we call a negative prediction error in neuroscience – basically the difference between what you expect and what the outcome is. When the outcome is not as good as the expectation, there is a negative prediction error, and these are correlated with negative mood. But negative mood is not necessarily a bad thing. It indicates that reality is not as good as I expect it to be. And so I need to act, I need to change it.

We are living in a world full of bias and discrimination. How do we dishabituate so that there can be change?
Say, for example, you go on a plane and the pilot is male. That's not surprising because we often see that pilots are male. So there's no prediction error, we don't react. And not only do we not react, our brain automatically infers why the situation is as it is – that males are probably better at navigating large equipment. And because we infer this thing that is not necessarily true, we then use those inferences to make decisions that can make things worse. For example, we're hiring pilots and, because of this inference, we'll be more likely to go with a male.

"Individuals who are slower to habituate are actually more creative"

The solution here is to make those discrepancies salient and to show how they are not rational. There is a professor at Princeton University called Yael Niv. She lists all the conferences in the neuroscience field and next to each is the name of the organisers, how many female and male speakers are at the conference and what the ratio is of males and females in that specific field.

So say there's a conference on computational psychiatry and the ratio is 60:40 in the population of people who do this, but then in the conference it is eight males and two females. That suggests the conference ratio is not quite right and that makes it very salient, and it also has accountability because there's the name of the organisers. No one wants to be associated with such discrimination. And so people are then motivated not to have this happen.

MATT MAWSON/MILLENNIUM IMAGES, UK

People stop noticing the pollution around them over time

Niv sounds like what you describe as a "dishabituation entrepreneur". Are some people less likely to habituate than others?
It's definitely a scale. What's interesting is that it has been found that individuals who are slower to habituate are actually more creative. If you're slower to habituate, you're more attentive, your brain responds to more sounds, more images, to more bits of information. And those individuals are the ones who tend to have more creative outputs.

Can just being aware of the fact we habituate make a difference?
Yes it can – and I hope it motivates people to try new things and take more chances, big and small. ▮

Alison Flood is comment and culture editor at *New Scientist*

The back pages

Puzzles
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***Almost* the last word**
When is the earliest I could survive in Earth's history? p46

Tom Gauld for *New Scientist*
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Twisteddoodles for *New Scientist*
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60-second psychology

The spiritual side of science

Could a greater appreciation of science bring the same health benefits that religion can provide for believers, asks **David Robson**

David Robson is an award-winning science writer and author of *The Expectation Effect: How your mindset can transform your life*

MY PERSONAL "road to Damascus" moment came through my TV set. I was 9 years old, and only mildly interested in science, when I caught a repeat of David Attenborough's *Life on Earth*, explaining the basics of evolutionary theory. Perhaps it was the sheer timescales involved, but I remember feeling physically dizzy as my mind slowly expanded to encompass these new ideas.

Should we describe these kinds of epiphanies – born from science, rather than religion – as spiritual experiences? That is the conclusion of a new paper from Jesse Preston at the University of Warwick, UK, and her colleagues.

The idea isn't entirely new. "When we recognize our place in an immensity of light years and in the passage of ages, when we grasp the intricacy, beauty and subtlety of life, then that soaring feeling, that sense of elation and humility combined, is surely spiritual," wrote Carl Sagan. But there hadn't been any experimental work exploring the idea until now.

Preston's team was inspired by research linking religious belief to better psychological well-being. One potential mechanism for this is through the emotions that spiritual experiences can inspire: awe, a sense of meaning and the feeling of connection to others, all of which can help to combat stress. It would be unfortunate if atheists and agnostics were excluded from these benefits. Fortunately, that doesn't seem to be the case.

The researchers' first step was to develop a psychological scale that examines the emotions

CARLOS FERNANDEZ/GETTY IMAGES

elicited by a greater understanding of the physical world. This was done by asking people to rate their agreement with statements such as "there is an order to science that transcends human thinking". They also included a question on "peak" experiences, those characterised by a state of euphoria – like the rapture I felt while watching *Life on Earth*.

Testing the resulting scale on 500 people, the researchers showed "spirituality of science" scores to be distinct from related measures, like a general belief in science as a means of rational inquiry. This suggests that the scale could capture the specific emotions otherwise associated with religion. In a further 526 participants, they then proved it could uniquely predict a range of well-being measures. People with higher scores had higher life satisfaction. This, the researchers argue, suggests that finding spirituality in science can provide the "existential support" typically experienced by religious believers.

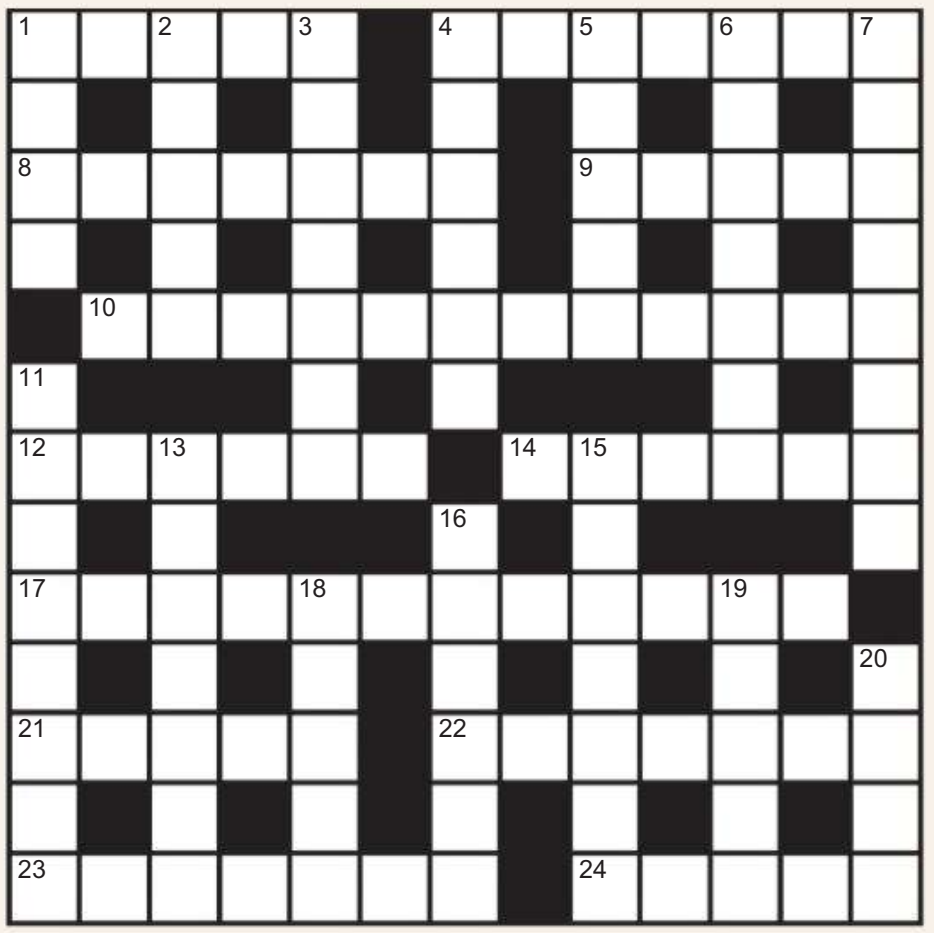
I hope this work opens the door to many more investigations. Some studies have hinted that religiosity can lead to better physical health, and I would be interested to see if the spirituality of science can do the same. In the meantime, I would love to hear more about your own experiences – those moments when new knowledge of yourself or nature blew your mind. Drop me a line on X @d_a_robson. ▮

These articles are posted each week at newscientist.com/maker

60-second psychology appears monthly

Next week
The science of baking

Cryptic crossword #130 *Set by Rasa*



Scribble zone

Answers and the next quick crossword next week

ACROSS

1 Plan borders of lime wood (5)
4 Plant polite chap alongside McKellen or McShane (7)
8 Mixed oil into chilled milk, say (7)
9 Once more trim cuter slips (5)
10 One news story intro follows unruly crowd with weakness for portable tech (6,6)
12 Thrill former spouse with mention in a paper (6)
14 Offer as incentive diamonds and degrees? (6)
17 Prisoners' exercise programme is restrictive (12)
21 Pub order multiplied by a digital assistant (5)
22 Swell bar has large facilities (7)
23 Shoe form protected by each sticky strip (7)
24 Messy study in need of a wipe-down (5)

DOWN

1 Physicist Planck discussed computers (4)
2 Become wan on egg diet (5)
3 Braggart got embraced by certain believer lacking depth (7)
4 Gizmo tagged bats (6)
5 Care for someone's skin after uphill race (5)
6 Cautiously moving end of pen into ancient Chinese text (7)
7 Went on first of trips probing unusual tree DNA (8)
11 For example, chromium disrupts light contraction (3,5)
13 Is able to briefly delete a unit (7)
15 Brontë sister and head of Latin name worm (7)
16 Fossilised resin under piece of concrete arch (6)
18 Vehicle backing into extremely tight lot (5)
19 On returning, approves recesses (5)
20 Just regularly join play (4)

Our crosswords are now solvable online
newscientist.com/crosswords

Quick quiz #241
set by Bethan Ackerley

1 Who was the first Native American person in space?

2 Which radioactive isotope was used in Little Boy, the first nuclear weapon used in warfare: plutonium-239, uranium-235 or uranium-238?

3 In what year was the first fully synthetic plastic invented?

4 What is the unit of electrical charge in the International System of Units?

5 A jellyfish's reproductive phase is also known by what name?

Answers on page 47

BrainTwister
set by Katie Steckles
#9 Rectangulator

Given a standard calculator keyboard, press – in order, going either clockwise or anticlockwise – four digit keys that form the corners of a square or rectangle on the keypad. This will create a four-digit number, e.g. 7469.

If the first button you press is the 7 key, how many possible four-digit numbers can you create?

What about if your square or rectangle is allowed to have a height or width of zero?

Can you show that for any square or rectangle you choose, the resulting four-digit number will always be divisible by 11?

Solution next week

Safe time travel

When I invent a time machine, what is the earliest period in Earth's history in which I could comfortably survive?

Reymond Aguinaldo
Ilagan, The Philippines
The answer depends on what you mean by "comfortably survive".

If you mean breathing the air, drinking the water and avoiding extreme temperatures, then you might be able to go back as far as the Ediacaran Period, roughly 640-540 million years ago (mya), when oxygen levels were closer to our own and there was abundant simple, multicellular life.

However, if you mean finding food and avoiding predators, then you might have a hard time in any period before the Holocene Epoch, starting around 11,700 years ago, when modern humans began to domesticate plants and animals.

Of course, you would also need to consider the risks of altering

"If you went back to the late Proterozoic (say 600 million years) you'd need to survive on an unappetising soup of cyanobacteria"

the course of history, creating paradoxes or encountering hostile civilisations. So maybe the best time to visit is the present.

Thomas Barker
Cambridge, UK
Earth's surface is thought to have solidified roughly 4 billion years ago, so any attempt to travel back earlier than that is certainly off the cards. Even after the mantle solidified, "comfortable" would be a stretch – almost all of the planet's surface was volcanically active, and there was next to no oxygen, so you would need breathing apparatus and a protective suit.

Earth's atmosphere remained almost oxygen-free until near the end of the "great oxygenation event" (around 2 billion years ago). It is thought that this raised Earth's oxygen concentration to 10 per cent of its present level, which is just about survivable for a few seconds.

Those are the absolute earliest points at which it is safe to try the time machine out. If you are planning to stick around in the past for a bit, though, you also need to worry about finding something to eat. Multicellular life doesn't enter the equation until the mid-Ediacaran Period (around 600 mya), and you will probably have to wait until the Cambrian explosion (around 540 mya) before any organisms are big enough to catch.

I would suggest the Devonian Period (starting at approximately 420 mya) as a good earliest point for long-term survival. Fish have evolved, oxygen levels are closer to today's and, in North America, the first forests are starting to grow. Wait a few more million years for the Carboniferous Period (roughly 360 mya), and you will even get to meet some of your earliest land ancestors, in the form of primitive tetrapods.

Bad luck if you are a vegetarian, though. Fruit won't evolve until the early Cretaceous Period (145 mya), so you are going to get pretty sick of eating ferns.

Graham Smith
Melbourne, Australia
If you were able to go back to the late Proterozoic Eon (say 600 million years), you would have barely enough oxygen to breathe for a short time, and you would need to survive on an unappetising soup of cyanobacteria.

Better to wait until after the Cambrian explosion so you could supplement your diet with shellfish. Better still, wait another 300 million years so that there will be plenty of land plants and animals to eat.

But don't wait too much longer, or you may become dinosaur food.

SHUTTERSTOCK/NEIRFY

Why are spring flowers mostly yellow, like these daffodils, with other colours appearing later?

This week's new questions

Bright spring **Why are so many spring flowers yellow, with other colours (such as blues and reds) appearing later?** ***Chris Barrett****, Malvern, Worcestershire, UK*

Dog legs **Unlike me, my dogs bound up hills as easily as they run on the flat. Does having four legs aid with climbing, or are the dogs just fitter than me?** ***John Kendall****, Machen, Gwent, UK*

Sense of direction

How did Roman road builders know which way to go? If they were a few degrees out setting off from, say, Chichester, they could have ended up in what is now Slough, not London.

Tim Lewis
Narberth, Dyfed, UK
At sea, the Romans used the North Star for direction, but on land, a series of beacons and a surveying instrument called a groma, comprising a staff with four plumb lines, were used.

Having set a beacon in Chichester, the surveyor would head off towards London, find a high point where the beacon could still be seen, set another beacon, and then would continue in this way with more beacons towards London. A groma was then used to line up the beacons, often moving them some distance until a straight route was achieved.

Robert Entwistle
Hon. editor of Itinera*: The journal of the Roman Roads Research Association*
This question nagged at the back of my mind for years, as the Romans had no magnetic compasses. In fact, most Roman roads weren't laid out in the precise way of Stane Street – the road from London to Chichester. They followed a series of approximations to reach their goal, visiting relevant locations along the way.

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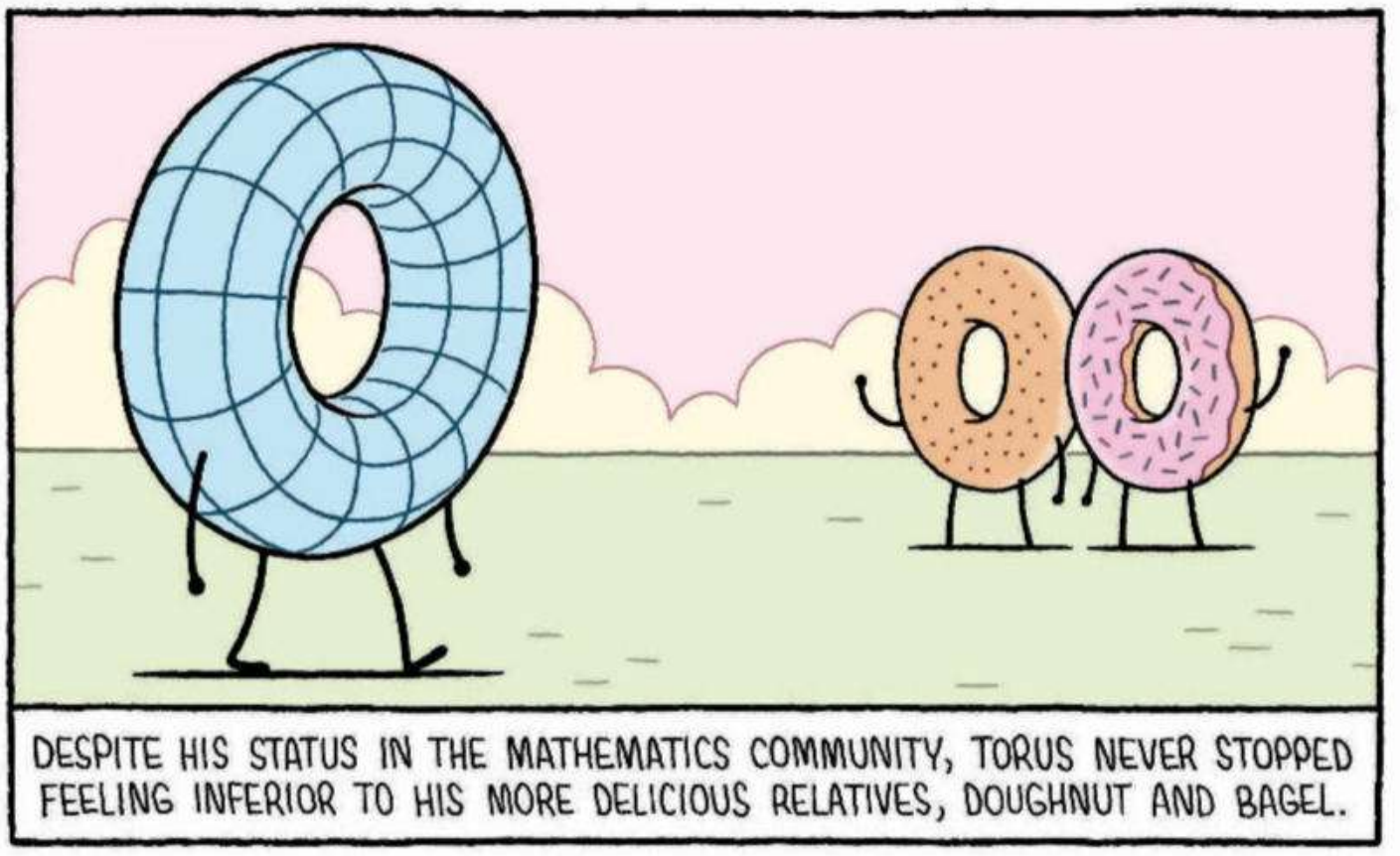
Tom Gauld
for New Scientist


DESPITE HIS STATUS IN THE MATHEMATICS COMMUNITY, TORUS NEVER STOPPED FEELING INFERIOR TO HIS MORE DELICIOUS RELATIVES, DOUGHNUT AND BAGEL.

The answer to why Stane Street is so precise is proposed in my book *Britannia Surveyed*. Soon after the Roman conquest of Britain, military surveyors planned a number of long, straight alignments (or traverses, in modern surveying jargon) from various key locations, as a way of understanding and mapping the new province.

Some of these traverses were used to establish locations for forts or military bases, and the military base that preceded Chichester was one. Sections of traverses were also later used by road builders (as the surveying had already been done).

Thus, Stane Street wasn't surveyed to lead directly from London to Chichester. Chichester was instead built on top of a Roman base that was on a line surveyed from the crossing point of the Thames (which became London). In other words, Stane Street simply followed part of an established alignment.

The line came first – the locations and road afterwards.

"Some Roman roads go straight over hills, when a slight curve around the hill could have made them far more manageable"

Hillary Shaw
Newport, Shropshire, UK
The Romans often straightened pre-existing trackways, which may not have been so crooked anyway. Ireland, where the Romans hadn't much influence, has some very straight roads. And Watling Street, the Roman road from London to Shrewsbury, isn't totally straight, but is a series of straight stretches set off from each other at angles.

Pre-Roman roads, often pilgrimage or trade routes, had to cross pinch points like rivers at easily forded locations, or go to sheltered bays where sea trade came and went. With a largely empty landscape in between, each section could be fairly straight anyway. Subsequently, these points acquired military or trade roles because people had to pass there, so forts and towns began to grow up.

Both London and Canterbury began at easy fording points of their respective rivers, the Thames and the Stour, and Chichester was a well-sheltered pre-Roman natural harbour. The conquering, colonising Romans simply adopted the existing landscape, its towns and the straight-ish earth tracks between them, and developed these with their innovations such as baths and even straighter paved roads.

Bart Bols
Scherpenheuvel-Zichem, Belgium
The Romans had a law that required straight parts of roads to have a certain width, and that value was doubled for sections with turns and curves. This made turns far more expensive to build, sometimes to the detriment of the road's effectiveness.

Roman roads are known for having gone straight up and over sizeable hills, when a slight curve around said hill could have made them far more manageable. ▮

Answers

Quick quiz #241 *Answers*

1 John Herrington, in 2002
2 Uranium-235
3 1907
4 The coulomb
5 The medusa phase

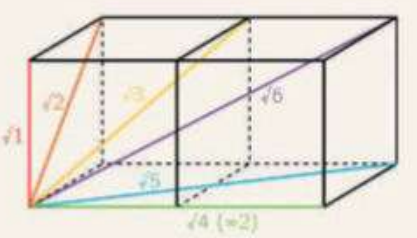
Quick crossword #152 *Answers*

ACROSS 7 Hedgehog, **9** Reheat, **10** Sums, **11** Lanthanide, **12** Caecum, **14** Melamine, **15** Potash, **16** Stones, **19** Trillion, **21** Arnica, **23** Flight deck, **24** Dome, **25** Sepsis, **26** *Star Wars*

DOWN 1 Nebula, **2** Eggs, **3** Thalamus, **4** Orchil, **5** Phenomenon, **6** Sardines, **8** Genome, **13** Cytologist, **15** Parallel, **17** Trackpad, **18** Angels, **20** IQ test, **22** Camera, **24** Down

#8 Two Cubes *Solution*

The points are $\sqrt{2}$ apart (using Pythagoras's theorem, the length of the diagonal is the square root of $1^2 + 1^2 = 2$). We can find pairs of points for all values of n from 1 to 6 by the same logic. The square root of 3 ($1^2 + (\sqrt{2})^2$) is the length between opposite corners of one cube. The long edge of the frame has a length of $\sqrt{4}$ (or 2), while $\sqrt{5}$ and $\sqrt{6}$ are the diagonals of the long face and whole frame, respectively. Sadly, a frame with a third cube added on the end won't get you $\sqrt{7}$ or $\sqrt{8}$, but it will contain $\sqrt{9}$, $\sqrt{10}$ and $\sqrt{11}$.



Intentional cattiness

When cats are forced to endure a crush of mass attention from an adoring public, do they continue to behave in their famous, endearing, imperious "cat-like" ways? Simona Cannas and her colleagues at the University of Milan in Italy produced some data that may bring attention to the question.

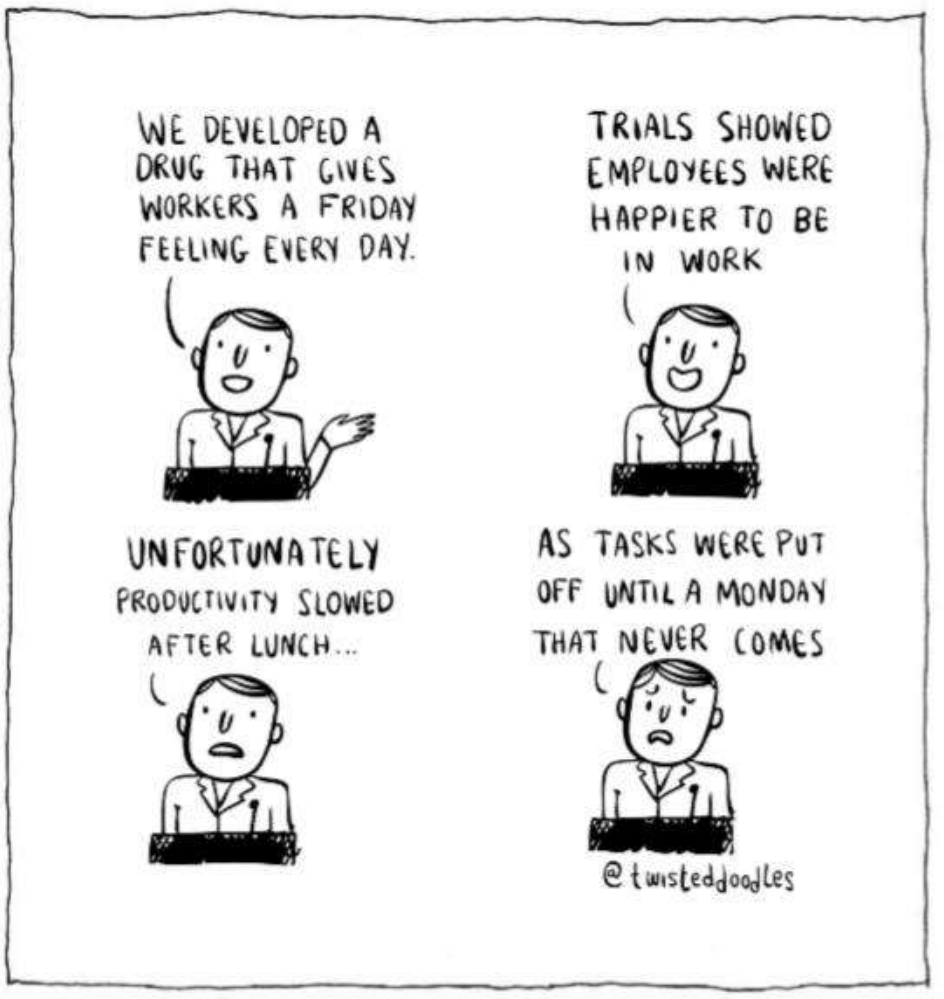
Their study, "Assessment of cats' behavior during a cat show", published in the *Journal of Veterinary Behavior*, focuses on 82 cats at a cat show. (The researchers, using professional lingo, say the event was "a feline exposition".)

They gathered the data meticulously: "the observer stood in front of the cages once an hour, from 10 to 17 [minutes past], for a total of 8 times for each cat".

They saw what they saw: "Analysis of behaviors exhibited by cats during the exposition day revealed that most of them were sleeping (93.9%), resting (62.2%), and looking at their surroundings (92.7%)."

The researchers' conclusion leaves room, still, for debate as to what those cats had in mind. The study says "the cat show environment represents a situation full of stressful stimuli for the cat; despite this, our results have identified few behaviors of discomfort or stress... Further studies are required to confirm and deepen our results."

Twisteddoodles *for New Scientist*


WE DEVELOPED A DRUG THAT GIVES WORKERS A FRIDAY FEELING EVERY DAY.
TRIALS SHOWED EMPLOYEES WERE HAPPIER TO BE IN WORK
UNFORTUNATELY PRODUCTIVITY SLOWED AFTER LUNCH...
AS TASKS WERE PUT OFF UNTIL A MONDAY THAT NEVER COMES
@twisteddoodles

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Consideration of items sent in the post will be delayed

What a yarn

Very long, thin things vary a lot in what their mathematician's-eye-catching length-to-thinness ratio makes it possible for them to do.

A press release from North Carolina State University hails the creation of "yarn-shaped supercapacitors", so called because the devices are thread-like and can behave as capacitors, controllably storing and disbursing electrical charge. The press release quotes Wei Gao, a co-inventor of the technology.

She said: "Imagine you can make a yarn, just a regular textile yarn, that you also make into a battery. You can basically hide it in your clothing. If you can do that, you can add so many more functions to your clothing."

We may be entering a technological Age of Thin Things.

As Feedback has noted (1 October 2022), a new city planned as part of Saudi Arabia's Neom project is designed to be 170,000 metres long by 200 metres wide. Could the North Carolinian yarn-shaped supercapacitor tech be incorporated into the Saudi city's exoskeleton? That would be a drastic leap to the future for a country that insists it wants to move beyond its current economic reliance on oil.

This suddenly-almost-plausible possibility shows the prescience of Wallis Simpson, former Duchess of Windsor, who is said to have said almost a century ago: "One can never be too rich or too thin."

Measuring addiction

The old saying "If you can measure it, it must be important" haunts the many research efforts to explain why it is important to measure two of the five fingers on a person's hand. Specifically, the second and fourth fingers. The two-finger quest kinda, sorta resembles an addiction. Sometimes this quest looks at addiction itself as being, maybe, something you can better understand by measuring fingers.

Typically, finger-ratio explanations grow in some vague way from the notion that hormone levels in the uterus before birth somehow explain the relative lengths, years later, of a person's fingers.

Finger-ratio-centric research studies are numerous and imaginative. They vary widely – almost wildly – in the kinds of important mysteries the researchers seek to explain.

How varied? Here are a few of the subjects addressed in recent years in published digit-ratio studies: "voice behavior in bankers"; "hunting success among Hadza hunters"; religiosity in university students; "parental income inequality and children's digit ratio"; artistic ability; "age at first marriage in semi-nomadic people from Namibia"; "psychological features in a sample of cavers"; bite injuries occurring in fistfights; "managerial skills of managers employed in public and private organizations of Udaipur City"; and "number of sex partners".

And addiction. Mehmet Gürkan Gürok and colleagues at various institutions in Turkey have recently written a paper called "Second and fourth (2D:4D) digit ratio in heroin and cannabis addicted patients". They published it in the *Journal of Ethnicity in Substance Abuse*. Like most finger-ratio studies, this one was done with great care: "We obtained the lengths of 2D and 4D of the subjects by using sensitive calipers and calculated the 2D:4D." And as is customary, it is full of promise: "Our findings can be considered promising as to whether prenatal hormonal factors are important in the etiopathogenesis of addiction."

The Denver sniff test

When something – and its headline – smells funny, maybe it is worth looking into. People who happen across a sombre study by environmental scientists in the US might react first to the ambiguity of its title: "Evaluating the environmental justice dimensions of odor in Denver, Colorado".

Was that title meant to be solemnly serious? Deadpannedly funny? Both? Whatever the intent, Feedback salutes its authors. Their wording triggered the olfactoric-linguistical sensibilities of Mason Porter, who alerted us to it. ▮

Marc Abrahams

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